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The Cover: A modern 60-stories-high antenna of KDKA, Pittsburgh, Pa., first established radio station. The 25th anniversary of radiobroadcasting is commemorated in this issue.

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Statements and opinions given in articles and papers appearing in *Electrical Engineering* are the expressions of contributors, for which the Institute assumes no responsibility. ¶ Correspondence is invited on all controversial matters.

Published Monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Founded 1884

VOLUME 64
NUMBER 10

WILLIAM E. WICKENDEN, President
H. H. HENLINE, Secretary

PUBLICATION COMMITTEE: C. F. Wagner, *chairman*; M. S. Coover; H. H. Henline; B. M. Jones; John Mills; J. J. Orr; H. H. Race; G. A. Van Brunt

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ELECTRICAL ENGINEERING

VOLUME 64, NUMBER 10 OCTOBER 1945

An Analysis of Electromagnetic Forces

WILLIAM A. TRIPP
MEMBER AIEE

Certain concepts of physics and electromagnetism conflict on several points, chiefly because of the latter's lack of general equations for the reaction of electrical particles. In this article the author introduces a few fundamental electrodynamic concepts and deduces from them some of the commonly used formulas for forces exerted on current-carrying conductors.

ELECTROMAGNETISM, the basic phenomenon of most of the processes involved in the production and use of electricity, is the force which practically moves the civilized world today. It is somewhat surprising, therefore, to find that certain fundamental concepts of electromagnetism do not conform with some of the concepts of general physics. One would think that at this late date the ground had been so thoroughly worked over that any possible points of disagreement would have been eradicated. It is true, of course, that the last few decades have seen such a complete revolution in the field of physics that scientific thought has far outdistanced many of the so-called practical sciences. It is not necessary, however, to embrace the more controversial tenets of the new physics, but only to borrow from some of the concepts which have proved their value and soundness in order to bring to light certain obscurities and inconsistencies which exist in electromagnetic theory.

The difficulty lies in the lack of general equations for the reaction of electrical particles. The engineer usually deals with mass phenomena, for which many formulas are available. The electrophysicist frequently deals with the activity of an individual charged particle but leans heavily upon the equations of the field, which really represent mass action. True, the mass formulas can be written in terms of currents which can be ascribed to the flow of a quantity of electrons, but this merely glosses over the missing elements by means of a change in the units of measurement and does not throw any light on the nature of the effects produced by the individual particles of electricity. A few investigators have offered formulas for the reactions of particles, but this information cannot be found in the textbooks and does not seem to have received general acceptance. One is confronted with the anomalous situation that it is possible to predict with a high degree of accuracy effects due to large numbers of electrons, but it is practically impossible to get the answer when only two particles are involved. The result is that, when a problem is encountered which cannot be reduced to or made to approximate one of the standard forms, such as cases involving so-called end effects, one finds oneself without adequate tools. Even in cases involving standard forms the available explanation is not entirely satisfactory or sound.

The force occurring between conductors carrying currents is one of the most important building blocks of electrical engineering. When the conductors are straight and parallel to each other this force represents one of the simplest geometrical configurations imaginable. If the conductors are of negligible cross section, and the distance between them is negligible compared with their lengths, the force per unit length of either conductor will have the value:

$$F=\frac{2I_1I_2}{S_d} \qquad (1)$$

where:

F=force, in dynes, on each centimeter of either conductor

I_1 and I_2=the currents in the conductors, in abamperes

S_d=separation between the conductors, in centimeters

The direction of the force is such as to tend to draw the conductors toward each other if the currents are in the same direction, and to separate them if the currents are in opposite directions. This has led to the concept that parallel currents attract if in the same direction and repel if in opposite directions. Up to this point everything could be proved by experiment, but now a conclusion has been drawn that may not represent the facts at all. It is a vastly different statement to say that the conductors tend to be drawn together or forced apart than to say that the currents attract or repel each other. The former statement recognizes that the forces involve the conductors as well as the currents, while the latter completely ignores the presence of the conductors. An error of viewpoint is involved, such as occurs in the explanation of the phenomenon known as "skin effect." It is explained as a crowding of the current to the outer portions of the conductor, and, while everybody who has to deal with this phenomenon knows that, conversely, it really consists of a progressive reduction in current density toward the inner portions of the conductor, the idea of crowding persists in popular parlance.

In the case of parallel currents, if it is the currents which attract or repel, this fact should be capable of experimental proof with the conductors eliminated, as, for example, the streams of electrons which make up cathode rays. A single heavy stream should tend to coalesce into a very fine but dense stream, while two parallel streams should tend to combine into one. Scientists have been working with such streams for many years but these effects apparently have gone unreported, although an actual case involving two streams does not seem to have occurred. It has been suggested, though, along with several other possible arrangements, by some popular writers on the subject. However, beyond a certain point the explanation becomes hazy and the description of the details of the proposed apparatus rather indefinite, with no clear indication that the author had ever tried the experiment himself.

Magnetic effects have been produced under carefully controlled test conditions by the physical movement of charged bodies. These experiments prove that charges in motion with respect to other charges produce magnetic effects, but there is nothing in them to prove that charges experiencing the same motion

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(that is, not actually moving with respect to each other) produce any magnetic effect upon each other. There is no ground for the belief that parallel streams of electrons in the same direction, whether as currents in a conductor, cathode rays in a tube, or accumulated charges on a body, attract each other because of a common absolute motion. If they did, it would be a simple matter to set up an arrangement to determine the true motion of the earth through space. The experiments referred to show that man-made speeds are sufficient to produce magnetic effects. When potential is applied to a conductor, current will begin to flow. This *fact* of current flow is transmitted along the conductor with something approaching the speed of light, but the actual *movement* of electrons along the conductor is relatively very slow. It is much like the flow of water in a pipe. If the pipe is full before the water starts to flow, the water will begin to move practically instantly everywhere along the pipe, but it will take some time for a particular drop of water to travel the length of the pipe. Some idea of the speed of electron movement in current conduction will be given in a subsequent paragraph. The important fact is that it is slow enough to be within the range of human experience. Thus, earth speed, such as its rotation, revolution about the sun, and galactic movement through space, should have a ponderable effect, with the result that all the electric meters in the world would be subject to a diurnal and seasonal correction. This would produce a most unhappy state of affairs for the electric utility companies, while careful scientists would be bedeviled eternally with an endless series of corrective measures. Fortunately, nature has arranged things for us better than that.

"UNNEUTRALIZED" PROTONS

All this discussion suggests that parallel currents in the same direction do not attract each other. With conductors carrying currents in opposite directions, there is clearly a relative motion between the electron streams, and the conclusion that the repulsive force results from this condition is logical. This leaves the attractive force to be accounted for between the electrons and the conductors. In electrical conduction, the conductors are assumed to be neutral, that is, composed of ordinary matter consisting of equal amounts of positive and negative electrical particles. The flow of current is assumed to be due to the motion of certain "free" electrons which are present therein and readily mobile under the influence of electrical potential. For every electron thus set in motion there must be a positive charge left behind, so to speak, still bound up in the atoms of the material, and remaining stationary. These may be termed the "unneutralized" protons, and it will be clear that their numerical count per unit quantity of conductor will be the same as that of the moving electrons. The moving electrons in one conductor therefore will be seen to be moving relative to the unneutralized protons in the other conductor, a condition which suggests itself as the seat of the attractive forces. This leads to the following propositions:

1. Like charges in relative parallel motion repel each other.
2. Unlike charges in relative parallel motion attract each other.

COMPONENTS OF FORCE ANALYZED

A full derivation of the actual magnitudes of the forces will be given in subsequent paragraphs. Let it suffice for the moment to say that since the observed forces, as evaluated by equation 1, are proportional to the product of the currents, they are a second-power effect and the individual forces on the particles must be proportional to the square of their relative speeds. Taking the case of the parallel conductors with the same value of current in each, and assuming for the moment that equal currents mean equal electron speeds (certainly true if one conductor is the continuation of the other), if the currents are in the same direction there will be two components of force on each conductor. One will be the force between the moving electrons in the one conductor and the unneutralized protons in the other conductor. The other component will be the force between the unneutralized protons in that conductor and the moving electrons in the other conductor. These two components will be of equal magnitude, and by the second proposition, both attractions. The total force on each conductor then is an attractive force of relative magnitude 2. Clearly there is no force between the stationary protons in the two conductors and, by all the preceding evidence, there is none between the moving electrons. They are moving in the same direction, at the same speed, and therefore not moving at all with respect to each other. Assume, now, that the current in one conductor is reversed. There will be the same two attractive components, as before, since proposition two considers only relative motion and does not establish preference as to direction. But a new component enters because of the relative motion of the electron flows in the two conductors. It will have a magnitude due to the same number of moving charges as the proton–electron force but double the velocity since the electron streams are moving past each other. By the square of twice the velocity, its relative magnitude will be 4, and by proposition one it will be a repulsion. The net force between the conductors thus will be the combination of an attraction of magnitude 2 and a repulsion of magnitude 4, or a net repulsion of magnitude 2. Reversing the current in one conductor consequently produces an equal force but reverses its direction, a result entirely in agreement with experience and equation 1.

Application of this concept should lead to a clearer explanation of some of the more obscure electromagnetic phenomena. A case of this nature is found in the "pinch" effect, observed in electric furnaces used to melt material by passing current through the charge. It has been found that when the charge becomes molten, if the current that is passed becomes too great, the charge tends to constrict or pinch in upon itself and reduce in cross section. The usual explanation, offered almost identically by different authorities, is that the current can be considered as a group of filamentary currents distributed over the cross section of the charge, and that by the attractive effect observed when currents are flowing in the same direction the filaments of the material of the charge are drawn together. This explanation always has seemed faulty, as it directs attention to the filamentary currents as the seat of the force, but requires that this force somehow appear on the material of the charge. The implication is that the electrons pulled or pushed (as suggested by one reference) the material of the charge inward as they themselves were drawn toward the center. As this is a case of electrical conduction, it would seem that the electrons are fairly free, not being bound very strongly to the atoms. It is therefore inconceivable that the electrons could pull any of the material along with them. It *is* conceivable that they would bump into atoms as they were drawn inward and in that way could be said to push the charge inward, but, with the turbulence in the furnace and the viscosity of the melt, it probably would be a rather slow process. Even the smallest atoms would have some 1,840 times the mass of the electrons that were trying to push them. Considered, however, in the light of the foregoing propositions, the phenomenon is adequately explained. With the flow of current through the melt, there will be "unneutralized" protons in the melt and, by the second proposition, there will be attractive forces between the electron streams and these protons. The net attraction on each is directed toward the common center of cross section, and the result is a pinching effect. By a process of mutual attraction both the charge and the current are drawn in.

There is no doubt that this effect is present also in ordinary metallic conduction, showing up as a magnetostrictive effect in the material and a tendency of the current to crowd toward the center of the conductor. The actual amount of crowding would be very slight, however. Electrostatic forces soon would arise as a result of displacement of electrons and stop its further progress, for the protons cannot travel inward and maintain the electrostatic balance as in the molten charge in the furnace. Electrostatic forces really are of tremendous magnitude, much larger than generally is realized, and a very slight displacement of electrons would be sufficient to counterbalance the electromagnetic forces of even a heavy current flow. This is truly a case of crowding, entirely distinct and different from "skin" effect.

The case of the parallel conductors does not lend itself immediately to the numerical solution of the forces between particles moving parallel to each other as there are nonparallel velocities present. It must be recognized that the particles in any portion of one conductor are moving toward or away from the particles in those portions of the other conductor which are not directly opposite. These "in-line" velocities may be expected to have an effect, which they do. Recourse may be had to a case where the in-line velocity forces cancel out, such as the circular loop carrying a current, with an electron located at the center of the loop and moving in the plane of the loop. This is shown in Figure 1.

The regulation electromagnetic analysis of this problem states that there is a magnetic field set up by the current I, the magnitude of which is $B=\frac{2\pi I}{R_c}(\mu=1)$ gausses at the center of the loop, and that the charge e_1 is acted upon by a force $F=Q_1V_1B$ dynes or $F=Q_1V_1\frac{2\pi I}{R_c}$, the direction being downward in the figure. Since the current in the loop actually consists of a stream of electrons moving in a counterclockwise direction (this necessary change in viewpoint as to direction of motion being the result of an unfortunate guess on the part of our scientific forefathers), then the force on electron e_1 must result from the relative motion between it and the electrons moving in the loop. It is possible to skip the intervening mechanism of the magnetic field and trace this force back to the reaction due to each electron of the current in the loop.

Taking any electron, such as e_2 in the loop, the relative parallel velocity between e_1 and e_2 will be $V_2+V_1\cos\alpha$, and the force resulting therefrom will be $\frac{Q_1Q_2(V_2+V_1\cos\alpha)^2}{R_c^2}$. This function for the force is arrived at by recognizing that the magnitudes of electromagnetic forces are evaluated in terms of the product of the currents involved and the inverse square of the distance of separation. From considerations previously discussed, this force will be a repulsion directed along the line joining the two electrons. The total net force F on electron e_1 will be the summation of all the individual forces due to all the electrons of the loop current. These individual forces are combined most readily if they are evaluated in terms of the same directional components, say a vertical component and a horizontal component. Recognizing that the current I must consist of a number, n_2, of electrons per unit length of the loop, moving with the average velocity V_2 such that $I=n_2Q_2V_2$, the vertical component of the force on e_1 due to the group of electrons in any small length dS_c of the loop, will be

$$\partial F_v=\frac{Q_1Q_2(V_2+V_1\cos\alpha)^2}{R_c^2}\cdot\cos\alpha\cdot n_2\partial S_c$$

$$=\frac{n_2Q_1Q_2}{R_c^2}(V_2^2\cos\alpha+2V_1V_2\times\cos^2\alpha+V_1^2\cos^3\alpha)\partial S_c$$

or since

$$S_c=R_c\alpha,\quad \partial S_c=R_c\partial\alpha$$

then

$$\partial F_v=\frac{n_2Q_1Q_2}{R_c}(V_2^2\cos\alpha+2V_1V_2\cos^2\alpha+V_1^2\cos^3\alpha)\partial\alpha$$

and

$$F_v=\frac{n_2Q_1Q_2}{R_c}\int_0^{2\pi}(V_2^2\cos\alpha+2V_1V_2\times\cos^2\alpha+V_1^2\cos^3\alpha)\partial\alpha$$

$$=\frac{n_2Q_1Q_2}{R_c}\left[V_1^2\sin\alpha+2V_1V_2\left(\frac{\alpha}{2}+\frac{\sin^2\alpha}{4}\right)+V_1^2\left(\sin\alpha-\frac{\sin^3\alpha}{3}\right)\right]_0^{2\pi}$$

$$=\frac{n_2Q_1Q_2}{R_c}\left[2V_1V_2\frac{2\pi}{2}\right]$$

$$=\frac{2\pi n_2Q_1Q_2V_1V_2}{R_c}=Q_1V_1\frac{2\pi n_2Q_2V_2}{R_c}$$

A similar analysis for the horizontal component of this force can be carried out. Its summation for the complete loop will be found equal to zero. There are other forces which can be identified as being present. These are: the force resulting from parallel motion between the electron e_1 and the unneutralized protons in the loop, and the forces due to in-line velocities between this electron and both the electrons and the unneutralized protons in the loop. It will be found that the summation of each of these forces for the entire loop also will be zero. In other words, the vertical component just evaluated represents the complete net electromagnetic force on electron e_1 due to the current in the loop. That is, $F=F_v=Q_1V_1\frac{2\pi n_2Q_2V_2}{R_c}$ and since $n_2Q_2V_2=I$, as explained above, then $F=Q_1V_1\frac{2\pi I}{R_c}$, which is the value given by the regulation electromagnetic analysis. From the correctness of the formula thus derived, it may be inferred that the original premise for the force due to the parallel relative velocity between any two particles is correct. For the geometrical configuration of the case considered this was given as $\frac{Q_1Q_2(V_2+V_1\cos\alpha)^2}{R_c^2}$. In general terms it may be written as

$$F_x=\frac{Q_1Q_2V_x^2}{S^2}\qquad(2)$$

where

F_x=force, in dynes, between moving particles
Q_1=charge, in electromagnetic units (abcoulombs), on particle number one
Q_2=charge, in electromagnetic units (abcoulombs), on particle number two
S=distance, in centimeters, between the particles
V_x=parallel relative velocity of the particles in centimeters per second

The line of the force is coincident with the line joining the two particles, and its direction is such as to constitute a repulsion if the charges are of the same sign and an attraction if they are of different signs. In this connection, it is worthy of note that the direction as well as the magnitude of the net total force for the case shown in Figure 1 was determined by a strict mathematical analysis, without recourse to any right-hand screw relationships or three-fingered perpendicularities, so difficult to rationalize and remember. It is to be noted that equation 2 gives positive values for repulsive forces and the net force for the case shown in Figure 1 came out positive for the direction which was assumed without prejudice, albeit with foreknowledge. This directional determination is a simplification in itself.

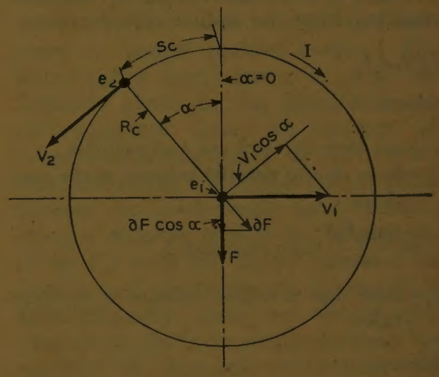

Figure 1. Diagram showing a circular loop carrying a current

R_c=radius of the loop, in centimeters
I=current flowing in the loop, in abamperes (clockwise)
Q_1=charge, in electromagnetic units (abcoulombs), on electron at center of loop
Q_2=charge, in electromagnetic units (abcoulombs), on any electron of current I
V_1=velocity of electron e_1, in centimeters per second, to the right
V_2=velocity of electron e_2, in centimeters per second, counterclockwise
α=angle which line between e_1 and e_2 makes with a selected zero position. This zero position is taken perpendicular to V_1 counterclockwise
F=force on electron e_1, in dynes

The evaluation of the forces due to in-line velocities now can be accomplished by taking a case where these effects do not cancel out, and separating from it the force due to the parallel velocities in accordance with equation 2. Such a case is found in the arrangement, previously discussed, of two infinitely long straight conductors, of negligible cross section, parallel to each other, as shown in Figure 2.

There will be a variety of forces present in this arrangement. Considering a unit length of conductor 1 at its midpoint, it will experience a force because of each of the following reactions:

1. The relative motion between the moving electrons in the given length of conductor 1 and all the moving electrons in conductor 2.
2. The relative motion between the moving electrons in the given length of conductor 1 and all the "unneutralized" protons in conductor 2.
3. The relative motion between the "unneutralized" protons in the given length of conductor 1 and all the moving electrons in conductor 2.

These three reactions can be evaluated in terms of the forces between the particles involved. Moreover, since we are concerned only with the attractive or repulsive force between the conductors, that is, the force perpendicular to their length, it is necessary to consider only the component of any of these individual forces perpendicular to the conductor.

The force between any two particles will be made up of two parts, that resulting from the parallel velocity and that resulting from the in-line velocity, or

$$f=f_x+f_y$$

where

f = net force between any two particles

f_x = force due to parallel velocity of the particles

$$=\frac{Q_1Q_2V_x^2}{S^2} \text{ from equation 2}$$

f_y = force due to in-line velocity of the particles

Assume

$$f_y=k\frac{Q_1Q_2V_y^2}{S^2}$$

where

k = a constant

V_y = the in-line relative velocity of the particles, in centimeters per second

Then

$$f=\frac{Q_1Q_2}{S^2}(V_x^2+kV_y^2) \quad \text{for the general case}$$

For particular cases:

Let

f_1 = the force between two electrons according to reaction one

Then

$$f_1=\frac{(-Q_1)(-Q_2)}{S_d^2+S_2^2}[(V_1\cos\alpha-V_2\cos\alpha)^2+k(V_1\sin\alpha-V_2\sin\alpha)^2]$$

$$=Q_1Q_2\frac{\cos^2\alpha}{S_d^2}[(V_1-V_2)^2\cos^2\alpha+k\times(V_1-V_2)^2\sin^2\alpha]$$

Let

f_2 = the force between an electron in conductor 1 and a proton in conductor 2 according to reaction two

Then

$$f_2=\frac{(-Q_1)(Q_2)}{S_d^2+S_2^2}[(V_1\cos\alpha)^2+k(V_1\sin\alpha)^2]$$

$$=-Q_1Q_2\frac{\cos^2\alpha}{S_d^2}[V_1^2\cos^2\alpha+kV_1^2\sin^2\alpha]$$

Let

f_3 = the force between a proton in conductor 1 and an electron in conductor 2 according to reaction three

Then

$$f_3=\frac{(Q_1)(-Q_2)}{S_d^2+S_2^2}[(V_2\cos\alpha)^2+k(V_2\sin\alpha)^2]$$

$$=-Q_1Q_2\frac{\cos^2\alpha}{S_d^2}[V_2^2\cos^2\alpha+kV_2^2\sin^2\alpha]$$

Let

f = the total force on unit length of conductor 1 due to all three reactions with particles in any small length ∂S_2 of conductor 2

Then

$$f=n_1f_1n_2\partial S_2+n_1f_2n_2\partial S_2+n_1f_3n_2\partial S_2$$
$$=n_1n_2(f_1+f_2+f_3)\partial S_2$$

Let

f_v = the perpendicular component of f

Then

$$f_v=n_1n_2(f_1+f_2+f_3)\cos\alpha\,\partial S_2$$

But

$$\frac{S_2}{S_d}=\tan\alpha$$

Then

$$\partial S_2=\frac{S_d\partial\alpha}{\cos^2\alpha}$$

Then

$$f_v=n_1n_2\left(Q_1Q_2\frac{\cos^2\alpha}{S_d^2}\right)[(V_1-V_2)^2\times\cos^2\alpha+k(V_1-V_2)^2\sin^2\alpha-V_1^2\cos^2\alpha-kV_1^2\times\sin^2\alpha-V_2^2\cos^2\alpha-kV_2^2\sin^2\alpha]\cos\alpha\frac{S_d\partial\alpha}{\cos^2\alpha}$$

$$=\frac{n_1n_2Q_1Q_2}{S_d}[-2V_1V_2\times\cos^2\alpha-2kV_1V_2\sin^2\alpha]\cos\alpha\,\partial\alpha$$

$$=-\frac{2n_1n_2Q_1Q_2V_1V_2}{S_d}[\cos^3\alpha+k\times\sin^2\alpha\cos\alpha]\,\partial\alpha$$

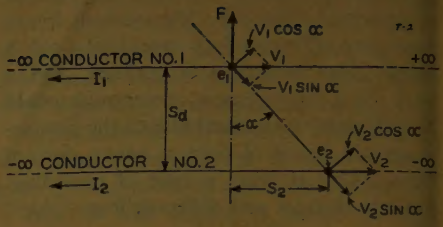

Figure 2. Diagram showing two infinitely long straight conductors

I_1 = current, in abamperes, in conductor 1 (positive direction to the left)

I_2 = current, in abamperes, in conductor 2 (positive direction to the left)

Q = charge on any electron or proton, being negative for electrons and positive for protons, in abcoulombs

n_1 = number of moving electrons or unneutralized protons per unit length (centimeter) of conductor 1

n_2 = number of moving electrons or unneutralized protons per unit length (centimeter) of conductor 2

V_1 = average velocity, in centimeters per second, of moving electrons in conductor 1 (positive direction to the right)

V_2 = average velocity, in centimeters per second, of moving electrons in conductor 2 (positive direction to the right)

S_d = distance of separation, in centimeters, between the conductors

S_2 = distance, in centimeters, of any point on conductor 2 from the midpoint of that conductor

α = angle which the line joining the midpoints of the conductors make with the line joining the midpoint of conductor 1 and any point on conductor 2 (midpoints of the two conductors assumed opposite each other)

Let

F = the total perpendicular force on unit length of conductor 1 due to all reactions from entire length of conductor 2

Then

$$F=\int_{\alpha=-\frac{\pi}{2}}^{\alpha=\frac{\pi}{2}}f_v$$

$$=-\frac{2n_1n_2Q_1Q_2V_1V_2}{S_d}\int_{\alpha=-\frac{\pi}{2}}^{\alpha=\frac{\pi}{2}}[\cos^3\alpha+k\times\sin^2\alpha\cos\alpha]\partial\alpha$$

$$=-\frac{2n_1n_2Q_1Q_2V_1V_2}{S_d}\left[\sin\alpha-\frac{\sin^3\alpha}{3}+\frac{k}{3}\sin^3\alpha\right]_{\alpha=-\frac{\pi}{2}}^{\alpha=\frac{\pi}{2}}$$

$$=-\frac{2n_1n_2Q_1Q_2V_1V_2}{S_d}\left[\frac{4}{3}+\frac{2k}{3}\right]$$

Since

$$I_1=n_1Q_1V_1 \text{ and } I_2=n_2Q_2V_2$$

Then

$$F=-\frac{2I_1I_2}{S_d}\left[\frac{4}{3}+\frac{2k}{3}\right]$$

But F is known to be equal to $-\frac{2I_1I_2}{S_d}$ (from equation 1 and negative because the currents have been assumed in the same direction and the force is an attraction).

Then

$$-\frac{2I_1I_2}{S_d}\left[\frac{4}{3}+\frac{2k}{3}\right]=-\frac{2I_1I_2}{S_d}$$

and

$$k=-{}^1/_2$$

The force between particles due to relative in-line velocity is, then,

$$F_y=-\frac{Q_1Q_2V_y^2}{2S^2} \qquad (3)$$

where

F_y = force, in dynes, between moving particles

Q_1 = charge, in electromagnetic units (abcoulombs), on particle number one

Q_2 = charge, in electromagnetic units (abcoulombs), on particle number two

S = distance, in centimeters, between the particles

V_y = in-line relative velocity of the particles in centimeters per second

For the general case, equations 2 and 3 may be combined, giving

$$F=F_x+F_y$$
$$=\frac{Q_1Q_2}{S^2}\left[V_x^2-\frac{V_y^2}{2}\right] \qquad (4)$$

In order to determine the direction of the force it is necessary merely to use the appropriate positive and negative signs of the charges on the particles and call the repulsive direction positive.

The negative sign of the V_y term in equation 4 may be a little startling as it means that when electrons are moving toward or away from each other there is an attractive force set up, while there is a repulsive force set up when electrons are moving toward or away from protons. What may be particularly surprising is that the force does not change sign with change in direction of motion. For instance, it is always a repulsion between electrons and protons, just the opposite of the parallel velocity effect. Interpreting this with respect to its physical significance, it means that when a conductor is carrying a current there is a longitudinal tensile stress set up in it, an internal force tending to stretch it. It has been shown that there is a magnetostrictive force set up under this condition which tends to contract the conductor radially. Its counterpart in the form of an axial stretching effect consequently may not be so surprising. This stretching effect does exhibit itself and has been noted but has gone unexplained. For instance, in the case of the pinch effect discussed previously, certain of the standard references include a statement to the effect that there is also a stretching effect in the material of the charge in the furnace which tends to elongate it in the line of current flow, but do not offer any explanation. It will be clear, however, that for any conductor of finite length there will be more electrons on one side of any given length of the conductor, except the very middle section. By equation 3 or 4 there will be a preponderance of force from that direction, which, by inspection, is a force directed away from the middle of the length of the conductor, or a stretching effect. Furthermore, if the formulas indicated that the force changed direction with change in direction of relative motion, it would predicate erroneously a net force tending to move the entire melt in the furnace in one direction, or any other conductor carrying current for that matter. Such a result would be contrary to observation and record. In other words, the formulas derived in this article are in accordance with observations.

"STRETCHING" EFFECT

It should be noted also that there is a "stretching" effect on the current itself. It might have been expected that the stretching effect on the conductor would be balanced, so to speak, by a compressive effect in the current, but this is not the case. It is found that the conductor and the current are stretching each other lengthwise just as they are compressing each other crosswise. The stretching effect in the current is, in effect, an internal voltage within the length of the conductor which, nevertheless, cancels out over its entire length. This, again, is to be expected, otherwise it would constitute a voltage with respect to the entire circuit and conflict with Ohm's law.

At an earlier point in this analysis, reference was made to the velocities involved in the flow of current in conductors. It was stated that these velocities are small in terms of ordinary experience. This can be demonstrated readily. According to the accepted concept of conduction, the flow of current consists of the movement of the free electrons associated with the atoms of the material of the conductor. Assume a piece of Number 12 American wire gauge copper wire carrying a current of ten amperes (=one abampere) such as occurs daily in home lighting circuits. A centimeter of this wire weighs about 0.294 gram and an atom of copper weighs about 1.06×10^{-22} gram. There are, therefore, about 2.78×10^{21} atoms in a centimeter of Number 12 copper wire. If each atom contributes one electron to the current flow, there are about 2.78×10^{21} electrons in motion in each centimeter. Each electron has a charge of 1.60×10^{-20} abcoulomb. Since an abampere is defined as a flow of one abcoulomb per second, and $I=nQV$, $1=2.78\times10^{21}\times1.60\times10^{-20}\times V$, V must be about 0.0225 centimeter per second.

This speed may seem amazingly slow, particularly in view of the rate at which the *fact* of current flow is transmitted along a conductor, which is something close to the speed of light, or nearly 3.00×10^{10} centimeters per second. It can be said that the voltage vector establishes itself at this tremendous rate and thus gets the current going, but this does not explain just what the voltage vector or electrical field is. It is left to the imagination of the individual to visualize how this vector follows the conductor and is confined thereto and directed along it, even through the intricate convolutions of a piece of electric machinery, while all the time he knows that potential effects appear across insulating materials as well as along conductors.

It would seem that the voltage vector is established by the creation of an electrostatic field along the length of the conductor by reason of a disturbance of the normally uniform distribution of electrons. It already has been stated that electrostatic forces are really tremendous, much larger than generally is recognized. This is because it is difficult to produce large unbalances of electrical charges on account of the great magnitude of the resultant effects. Something will usually let go before the unbalance becomes very great, and we have become accustomed to think in terms of the smallness of the unbalance instead of the relatively huge effect caused by the small unbalance. Some idea of this relationship is gained by considering the relative magnitude of electrostatic and electromagnetic forces between particles. Equation 2 gives the electromagnetic force between two electrons in relative parallel motion. This formula has been shown to yield the formulas given in the handbooks for electromagnetic forces for standard arrangements of conductors. It will be noted that this formula is similar to the handbook formula for electrostatic force between charges, differing from it by the presence of the V_x^2 term and by the fact that the quantity of electricity is measured in electromagnetic units or abcoulombs, whereas in the electrostatic formula the quantity of electricity is measured in electrostatic units or statcoulombs. The ratio of these two units is 3×10^{10} which is numerically equal to the velocity of light, so that the relative velocity would have to be equal to the velocity of light for the electromagnetic force to be equal to the electrostatic force. However, it has just been shown that electric currents involve velocities which are probably only a small fraction of a centimeter per second. Since the force is proportional to the square of the velocity, the comparative puniness of electromagnetic force can be imagined. And yet this is the force which practically moves the civilized world today.

In view of this relationship of magnitudes, it is evident that it would not require much of a variation in the concentration of free electrons along a wire to establish the necessary potential gradient. In the number 12 American wire gauge copper wire considered earlier, the resistance is about 1.62 ohms per 1,000 feet under standard conditions. This means that to cause one abampere (ten amperes) to flow, 16.2 volts per thousand feet, or 0.000530 volt per centimeter, direct current, is required. The rate at which energy is consumed per centimeter of wire length in causing this current to flow is $10 \times 0.000530 = 0.00530$ watt. As has been stated, there are about 2.78×10^{21} electrons per centimeter involved, moving at an average velocity of about 0.0225 centimeter per second. If there is an average force of f dynes acting on each of these electrons, the energy consumption would be $2.78 \times 10^{21} \times 0.0225 \times 10^{-7} \times f$ watt per centimeter. Since this must be equal to the above value of 0.00530 watt per centimeter, the average force on each electron must be equal to 8.48×10^{-16} dyne.

This force may be considered a result of a greater concentration of electrons on one side than on the other. This would mean that the concentration of electrons in the wire increases toward the negative end. The rate at which this concentration would have to vary along the wire may be calculated by straightforward electrostatic methods, and comes out something of the order of 1.55×10^{-11} per cent per centimeter when the concentration is 2.78×10^{21} electrons per centimeter, or a variation of about 4.31×10^{8} electrons per centimeter. Another way of looking at this is in terms of the spacing of the electrons. At the density of 2.78×10^{21} electrons per centimeter, the spacing is about 2.28×10^{-8} centimeter between electrons and differs by only 1.55×10^{-11} per cent from the concentration in the next centimeter. This small spacing and the small variation required in it to produce the necessary potential along the wire make it clearer how current can go through the many convolutions and contortions required of it and still permit the voltage vector apparently to be directed simply along the conductor in any machine that can be built by human hands.

This digression on the subject of current conduction has been included because it seemed to bear some relation to the general subject of electron reactions. In ordinary cases, where the arrangements correspond reasonably closely to standard forms, the relationships may be worked out by means of the usual engineering methods for which the formulas are to be found in the handbooks. The propositions advanced in this analysis should be of practical assistance, however, in the solution of unusual and obscure cases, and cases involving so-called end effects and other configurations which cannot be reduced to standard forms. It has been customary to break nonstandard arrangements up into parts which individually can be made to approximate some standard form, but too great a dependence on the accuracy of this method must be cautioned against. It is better to apply the formulas for the reactions of the individual electrons, which can be used to good advantage, as has been shown in some of the cases discussed. Recognition of the necessity for relative motion in order to produce electromagnetic effects, and segregation of the parallel and in-line velocities, should lead to the explanation of many effects and the observation of others. In a broad sense, it may be expected that electromagnetic effects can be ascribed to many cases which involve apparently static charges, but where these charges, although stationary with respect to the observer or the observer's "mass" viewpoint, actually may not be stationary with respect to other charges in the neighborhood.

The Engineer in the Postwar Period

R. P. MEILY

A shortage of qualified engineers in the postwar period is foreseen in this article, in which industry is urged to aid itself. In particular, industry is urged to train a number of young engineers each year regardless of business conditions.

TWO FACTS stand out clear and sharp against the postwar years ahead: First, engineers will have unprecedented opportunity; and second, industry should start now to conserve technical talent in every way and help train new engineers as quickly as possible.

These conclusions are inescapable. Engineers will be scarce because:

1. When the war ends, industry will have fewer competent engineers than in 1942, and none in training.
2. It will take time to bring returning engineers up to their former efficiency.
3. Colleges will not graduate engineers for several years.
4. There will be no flow of engineers from war-born industries battling to stay in business.

On top of these conditions will be the pressing commercial urge to freshen and market former standard products as quickly as possible while new products are still in the making. With a huge reservoir of technical knowledge ready to be put to work, practically all of these new products will require more engineering than ever before in order to be competitive. These approaching conditions in industry all add to make a period of unusual opportunity for good engineers.

The problem industry will face after the war has its roots in the early 1930's. During the depression many experienced engineers were released by industry. No young engineers were being brought in for training as replacements, resulting in a present void in the ranks of engineers in the age group now 30 to 40 needed for wartime engineering. Had this group been in training and available in 1942, industry would have spared itself a great deal of money and time that went into training programs of all sorts which often turned out to be costly makeshifts. Design, development, and production would have gotten off to a quicker start with less waste of manpower and materials. Industry has had to bid in the open market for engineers and then train those engineers on the job—and this at a time when there were very few engineers available.

Engineers found their services also were being sought eagerly by Government as well as by industry. A large portion of the young engineers had reserve officers' training and were immediately commissioned. Those with engineering backgrounds were naturally attracted to the services, thus adding to the shortage of available men. Industry then was forced to employ a large number of young graduate engineers and train them on the

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job. This eventually failed as practically all of those under 29 finally were inducted into the service.

ENGINEERING RANKS DEPLETED

At present, industry is undermanned in engineering talent, both as to quantity and quality. The fault is not the engineer's, but lies in the fact that industry allowed ten years to pass during which too few engineers were in training. The engineers in industry are generally over 40. The void in the age group 30–40 never will be filled, and the lack of men in this bracket will continue to be felt for the next 20 years, reaching the maximum in about 1955.

Although nothing can close this gap, the future flow of new engineers over the years matches industrial requirements nicely; that is, fewer older, experienced engineers are required than younger, inexperienced men. The small group of seasoned engineers will fill the executive and supervisory positions to guide and safeguard the younger engineers. However, a gap in the training of engineers as in 1929 and 1939 becomes more serious to industry as age increases. There will be relatively few engineers in the age group 50–65 between the years 1955–65. The deficit must be made up from the ranks of engineers 45 years old, who may be lacking in experience and judgment. To prevent a repetition of this condition, industry should bring into its organization each year a basic number of young engineers from each graduating class regardless of the state of business. This provides minimum insurance.

In the interest of strengthening and maintaining adequate engineering personnel for the immediate postwar period, it would be well for industry to analyze the probable demand and the supply of engineering talent.

Many young engineers will probably elect to remain in the service of the Government. There is ample evidence of the necessity of maintaining a large Army and Navy, which will require much engineering talent of high order. New weapons and techniques will become more and more technical, and the higher the degree of mechanization, the more specialized must be the people who are to design, develop, manufacture, operate, and service the equipment.

In parallel with a scarcity of technical help during the immediate postwar period, industry faces a large pent-up demand for manufactured goods. Industries in a position to supply such goods at once will skim the cream of the business. But by advertising and other means, the public has been led to expect marvelous product changes all along the line; and this public will no longer be satisfied with a new 1942 model automobile, refrigerator, or radio. It will be necessary, therefore, for industry to make good quickly on some of the promises.

To bring out a new or improved product has generally been a long process of development and experiment followed by the creation of specialized machinery and manufacturing processes, all requiring much time. The urge will be to accomplish all of these things quickly; and the people who do these things are engineers. The fact that things must be done quickly, in itself, means larger engineering staffs.

Of necessity, new products will be more highly mechanical and technical than prewar products. The public looks forward to finding ingenious principles used in war applied to industrial, commercial, and home uses.

In addition, the public will not only be product conscious, but price conscious; perhaps not at first, but increasingly so as more goods become available. This means a highly competitive situation, requiring the best in engineers all along the line.

This trend will affect the sales forces of industry when they are expanded from their present wartime skeleton. New products will call for more highly specialized sales and service training. Many of these men must have engineering training. Indeed, it would seem that industry will not be able to get by in terms of services previously rendered.

There are three principal ways in which industry can help itself:

1. Keep the good engineers already in its service contented; and use these engineers at their highest skills. Industry has already taken steps to keep its engineers. Such factors as seniority, wage reviews and raises, and pensions work in this direction.

2. Industry must recruit engineering forces from outside sources and institute training programs which will quickly make these engineers productive. In attracting new engineering talent from outside sources, industry finds itself in a highly competitive position. The well-established industry with accepted products will have the advantage, but it will have to offer pay rates commensurate with ability and opportunity and all the usual standard employee benefits. Engineers will be scarce, and many are going to be money conscious.

3. Industry must look to the colleges for young engineers when the colleges again graduate engineers. It may be three or four years or more before the colleges can be counted upon for such men in normal numbers. When graduates are available, a liberal number should be placed in training which will fit them for service in the shortest possible time. The young graduating engineers can be discounted for the immediate postwar period, because there will be so few of them in the next four or five years, perhaps longer, that their presence will have little influence in the over-all result.

The immediate problem which industry faces with regard to engineers is made more serious by the current desire of engineers to change jobs. The unrest can be attributed to the fact that industry is taking every means at its disposal to build up a strong engineering force in preparation for postwar activity which creates the job market. At the same time, engineers in strictly war industry are looking for more secure postwar opportunity. Many, because of salary stabilization, are also hoping to better themselves by a change. All things considered, it appears that the immediate future of the engineer is for more recognition and increasing responsibility.

Hydroelectric Expansion in France

By expanding her network of hydroelectric plants and increasing production of existing plants, France hopes to compensate, in some measure, for the acute coal shortages now paralyzing her vital industries. French engineers have three programs for expansion of the system.

Although the first program, that of 1938, never was completed entirely, dams constructed under its provisions are now supplying France with 1,200,000,000 kilowatt-hours of energy. Two more large dams, l'Aigle and St. Etienne de Cantales, may be completed by the end of the year, while a third, Genissiat, cannot be finished before the end of 1948. The 1941 program provided for construction of 49 dams supplying 5,250,000,000 kilowatt-hours. Only the Thués Dam in the Pyrenees is nearing completion, but work is under way on 18 smaller dams which will furnish 2,000,000,000 kilowatt-hours. The two most important, Bort-les-Orges (400,000,000 kilowatt-hours) and Chastang (540,000,000 kilowatt-hours), both in the Massif Central, may be opened in October 1949. Still in the blueprint stage are the 46 dams provided by the 1945 program, including the giant Donziere Montdragon on the Rhone River, which will supply France with 5,600,000,000 kilowatt-hours. Engineers hope that dams completed by the end of 1945 will supply over 1,000,000,000 kilowatt-hours to the Massif Central and 360,000,000 to the Pyrenees, thereby saving 1,000,000 tons of coal. It is estimated that four months after the opening of these plants, enough energy will have been supplied to compensate fully for the coal used in their operation.

In order to utilize these plants to capacity, France must also put up a new network of high-voltage transmission lines. Three years will be required to build 1,500 miles of high-voltage wires carrying from 60 to 220,000 volts.

One Facet of Naval Electrical Research

ELLSWORTH F. SEAMAN
MEMBER AIEE

Research is a significant element in the field of naval electrical engineering as it is in all scientific fields. In this article the author takes cognizance of the general subject but concentrates on one phase of naval electrical research; that concerned with the adaptation of shipboard equipment to wartime conditions, a period of unlimited demand and limited supply.

THE TERM "RESEARCH" is one of the most imaginative of the words forming our scientific and electrical vocabulary and as such lends itself to many definitions and interpretations. It is, however, our immediate concern to examine one particular facet or concept of this word, and its relationship to the scope of naval electrical engineering.

For this purpose it is convenient to think of research in terms of its cause and effect; the cause as the need for a new type of service material, or necessity for improvement of an old material, and the effect as the reduction to practice through research, development, and standardization. The picture as a whole may be likened to an Archimedean spiral where the center point represents the initial inception of the problem and where the line of the spiral represents that research work necessary to advance the problem to the development point. The line then carries us through the final performance stage to standardization and a Navy specification representative of the minimum satisfactory performance level for shipboard material. Service experience determines if and when further research is necessary. When this is the case the spiral of research progress continues in a repetitive pattern but it encompasses an ever-expanding field of knowledge.

This is a concept of research in its broadest aspect since it is inherently and inseparably related, through the foundation it builds, to the successive and progressive steps of development, standardization, and operating experience. The cycle thus defined depends for its initial, and for each succeeding, impetus on that research that evaluates performance of materials and equipment, that seeks out and develops new materials, that measures and simulates service performance in the laboratory, and that visualizes future problems in time for their solution before the emergency arises. In other words, research properly planned and conducted develops new concepts. The new concepts enable one to visualize and anticipate future needs.

OUTSIDE RELATIONSHIPS

The laws of physics recognize no limiting boundaries that allocate new materials and equipment to one particular field of application. Thus it is that research, and especially research of the more basic type, is of universal interest and provides common ground over which the engineer or scientist must pass in traveling from the field of domestic or industrial endeavor into the more specialized sphere of military requirements. It is true that specialized needs, where they are sufficiently important, establish research trends in the private laboratory and lead to the development of new and significantly different materials. It is, however, also a fact that ability to accelerate development of special naval material or equipment sometimes depends on the commercial background available and on scientific advances.

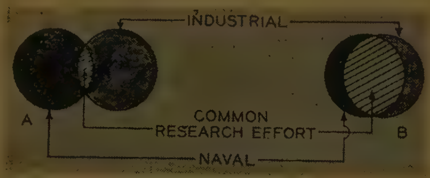

Figure 1. Outside relationships

A. Peacetime condition
B. Wartime condition

In speaking of naval electrical research the picture would not be presented in its true perspective if this research were assumed to have nothing in common with that of other branches of the Armed Forces. In some cases the problems are identical and research for one provides the answer for both. This thought has its foundation, in fact, where certain Bureaus of the Navy and Services of the Army are working jointly in their laboratories on common problems. This work grows out of, and forms the basis for, Joint Army–Navy standardization work that is well advanced and has to its credit numerous *JAN* specifications.

It is, therefore, apparent that research progresses most effectively and rapidly through a thorough knowledge of the purpose it serves in the fields of development and standardization and through its common-interest linkage with industrial laboratories where answers in the form of new and needed materials already may be in the making.

SCOPE

The scope of research is inherently that of the problems requiring solution. The limitation to the degree of perfection attained is the limitation engendered by our working materials and our ability to mold them into a most effective end result. Thus, the starting point in electrical naval research is the matériel phase, where, through research intended to produce new or improved materials or through ingenious design combinations, it is possible to bring about a performance objective. The likelihood of achieving this end depends on the severity of the service requirements, commercial availability, scientific talent, and long-range planning.

Material as such lends itself to the generic classifications of dielectrics, conductors, and structural parts so combined as to present the most effective assembly of the dielectric and conductive units. Design, arranged chronologically, passes through the successive steps of:

1. Component part or individual unit.
2. Equipments composed of individual units.
3. Systems made up of equipments.
4. Co-ordination of systems.
5. Warcraft designed by utilizing most effectively a combination of these steps.

Starting initially with the broader perspective we may evaluate the over-all picture and subject to review any of its parts for purposes of improvement through research.

The research scope can be defined more concretely by specifying the major service requirements for which equipment and materials must be developed when they are not available. These numerous service conditions include the following representative and more important factors:

(*a*). High humidity.

(*b*). Excessive temperatures.

(*c*). Shock and vibration.

(*d*). Extremes in operating conditions (from northern latitudes to tropical or torrid zones).

(*e*). Necessity for maximum reduction in weight and space for equipment.

Essential substance of an address presented at a meeting of the AIEE Worcester Section, March 9, 1945.

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These conditions must not only be effectively dealt with, but the end product should be simple in design, possess a long service life, and in many instances be required to perform unusual functions.

Thus far our discussion has dealt with generalizations relating to "concept," "outside relationship," "scope," and "special problems" that are found in the electrical naval research field. It is the purpose now to amplify these ideas and in this manner to emphasize some of the patterns that are found useful in thinking of naval research in the electrical-engineering field.

SPECIFIC ASPECTS OF RESEARCH

On considering research we may note a complete cycle consisting of the research, development, standardization, and operation phases of, so to speak, a rectangular spiral.

The steps then repeat if and as necessary, depending on the needs of the service. Each advancing step in the pattern represents a composite of the background plus what is made possible of achievement because of this background.

From Figure 1 it is apparent that two spheres of activity can be considered as distinct and separate but that a common ground or common linkage exists to join the two. This common area is at all times the more basic research, but with less frequency it extends into specific application improvements such as increase in heat and flame resistance of electrical insulation which represents a development that is commonly useful throughout electrical industry. It has been accelerated in this instance, however, by the urgent shipboard needs for heat- and flame-resistant dielectrics.

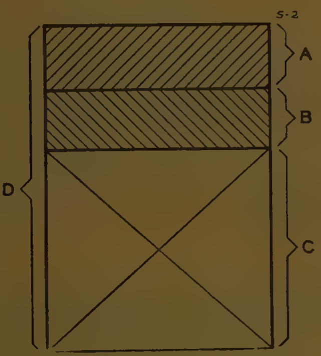

Figure 2. Special problems

A. Size reduction; apparent development
B. Size reduction; real development
C. Optimum equipment size
D. Standard frame size

It should be of interest to engineers to think of the scope of research in terms of an algebraic equation where it is possible to define as quantity A the required service performance and quantity B as the matériel available to meet the needs of A. In this case the end performance C must be equal to or greater than B/A. If $B/A<1$ research is necessary. Performance A as a whole might be summed up as the life period under accelerated aging conditions where ruggedness is adequate and where deterioration of the insulation has not taken place to the extent that a failure is likely to occur. This resolves itself into a problem of the adoption of a truly indicative accelerated aging test which is one of the most difficult things to accomplish as it must be correlated over long periods of time with control samples that are subjected to normal full-lifetime tests.

Figure 3. Glass jewel used as instrument bearing

These tests, as an expression of service conditions and operating requirements cover

1. Life (accelerated aging).
2. Moisture resistance.
3. Vibration and shock resistance.
4. Heat and flame resistance.
5. Fungus resistance.
6. High electrical characteristics.
7. Special functional requirements.
8. Oil resistance.
9. Space and weight resistance.

Passing to performance B it will be seen that the characteristics of material and equipment are measured by the test standard adopted for actual service simulative operation and, as previously stated, if C is not greater than one, then research and development are indicated. This is undertaken through experimentation in new materials or equipment-design improvements in order to achieve the necessary end result. Performance C is this end result.

The manufacturing industry must, in order to accomplish production results, arrange for fabrication on a production-line basis. This production in some of the more common equipment means that the same machinery-frame size will be used from a fractional part of this frame-size capacity up to 100 per cent of the frame rating (Figure 2). This will be repeated when the next step in frame size is reached. Where space and weight warrant the change it is necessary through naval development to reduce the frame size by the amount A. This may be termed apparent development. If, however, it is possible to reduce further the frame size of the equipment by the amount B through utilizing a newly developed heat-resistant insulation while retaining the same rating, we have entered into and completed a phase of real development.

CONTRIBUTING FACTORS

Naval electrical research has been described thus far in terms that are general in character. Perhaps the word "philosophy" would define the approach more accurately. Subsequent paragraphs offer brief, pertinent comment on a few of the other subjects involved in electrical research. The diversity of these subjects serves to emphasize further the scope and the research interest that this field comprises.

Fungus. The part fungus plays in electrical research is an important one. The types of fungus are numerous as experiences in the South Pacific have shown. Fungus eats up the electrical insulation and in some cases reduces the nominal 20-year-life period to a few days. The problems engendered by this condition are manifold. They consist of finding effective fungicides or of developing insulation that is inherently fungicidal in character, as well as developing, in the laboratory, service simulative testing procedures. Presence of moisture has been found to be important in supporting the growth of fungus. Hence the normally important problem of moisture-resistant shipboard equipment and material takes on an added significance where climatic conditions are such as to encourage fungus growth. Our studies in this connection comprise a study of the effect of different fungicides on various fungus cultures, while at the same time retaining good electrical properties in the material.

Figure 4. Magnet-wire insulation

Glass Jewel and Vibration Test. A large number of electric indicating instruments are used aboard naval ships where the conditions of continuous vibration and intermittent shock tend to reduce the accuracy seriously by attacking the instrument bearing, one of the most vulnerable points in the instrument design. These bearings formerly were imported natural sapphires, but during the war emergency the industrial field developed synthetic sapphires as well as specially treated glass jewels to meet the needs of the Armed Forces. Much has been learned of jewel performance as a part of the electric-

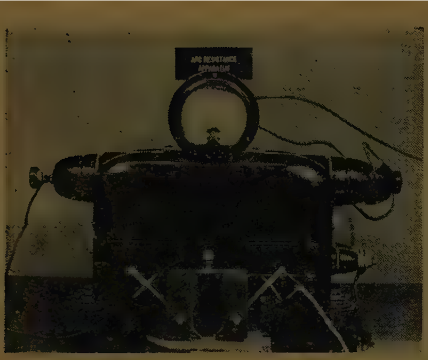

Figure 5. Arc-test apparatus

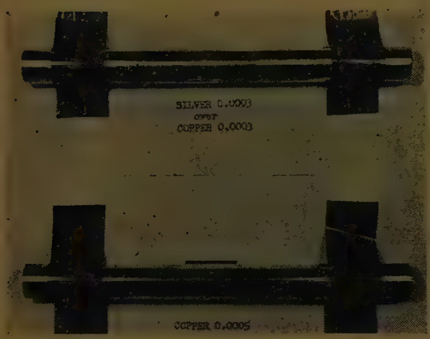

Figure 6. Copper- and silver-plated insulating plastics

instrument design and much of the information has been made available by testing on the vibration-test stand. The particular jewel bearing illustrated in Figure 3 is glass and is slightly larger in actual size than a pinhead.

The electric indicating instrument of which this jewel bearing is a part is tested on a vibration machine. The frequency and amplitude of the vibration are adjustable up to 2,000 cycles per minute and 1/16-inch or 1/8-inch total travel. The movement of the mounting plate that holds the test sample is such as to simulate that existing aboard a ship or plane. It is possible by adjustment of the frequency and amplitude to observe the performance of the test sample at its natural period or resonance condition.

Mica. Mica is a dielectric material that has been invaluable for electrical applications requiring inorganic materials. It has been used for a number of years but the demand for this type of insulation is still practically undiminished. World War II in no way reduced the requirements for electrical purposes but, instead, brought to the fore the fact that even more use must be made of materials available during a period of critical shortage in order to supply the quantities desired, and that more accurate measurements must be devised for determination of electrical quality. In the past, color has been one of the criteria used to select mica quality for electrical applications. It now has been determined through the use of more accurate methods of measurement that color in itself may not be truly indicative of performance limitations of the material. The answer which has developed along these lines has been the result of joint research work on the part of the Armed Forces and outside laboratories. This is a demonstration of the results of research that have been useful in providing a wartime answer by the reduction of the critical status of electrical insulating materials through refined measurement methods and consequent use of greater quantities of the available material.

Magnet Wire. Figure 4 is an illustration in applied form of an insulating film which has been subjected to thousands of hours of heat endurance in order to determine its operation limitations. While the cracks that are observed are not in themselves an accurate measure of failure, they are a true indication of the approaching end of useful life if the end of life is defined in terms of low dielectric strength or low insulation resistance at high-humidity conditions. Research has been extensive in the direction of increased life for insulating varnishes that are required to operate at excessive temperatures, high humidities, and exposure to oil and grease. There is also the problem of considerable mechanical dimensional change in the electric machinery occasioned by the extremes of high operating temperatures and low temperatures while idle. This magnet-wire illustration is a specific application of what might be termed a particular type of synthetic resinous varnish applied in thin film form. Much work has been and is being done on magnet-wire insulation as it forms the basis for electric-machinery design and the continued dependability of this machinery aboard ship where it is vital to the effectiveness of the vessel as a combatant unit.

Application of Statistical Analysis to Electrical-Engineering Research. Table I shows an apparently simple tabulation of numerical values that is potentially more spectacular in its significance in research and the extension of the research horizon than any of the material manifestations that previously have been discussed. This particular table is a summarization of test data taken with a particular type of test machine and representative of a certain product of two manufacturers. The test problem was to measure the relative quality of the two products on several test machines of identical designs. The engineer's attack on such a problem would be to tabulate extensive data by repetitive testing and then to analyze the information for significant variation in performance as indicated by a measure of the number of failures. The mathematician, however, observes that a multiplicity of variations occur simultaneously to effect the final results and to the extent that it is beyond the capacity of human physical conception to separate effectively the significant values.

He observes, for instance, after consultation with the research engineer that, for the particular test illustrated, the following factors vary simultaneously:

1. Variation in the manufacturer's product.
2. Variation in testing machines.
3. Variation in test results due to difference of mounting location on the test machine.

There are added variations over and above the main effects such as factors 1, 2, and 3, which result from interactions between these factors. These, when they exist, are independent of the main effects. If left undetected in the experiment the researcher has that feeling that is persistently present when data have been analyzed; that is, if one more test had been conducted the complete answer would be forthcoming and conclusive. The use of this statistical procedure obviates such feeling of frustration.

Table I. Application of Statistical Analysis to Electrical-Engineering Research

Position	I			II			III			IV			Average		
	(A)	(B)		(A)	(B)		(A)	(B)		(A)	(B)		(A)	(B)	
1	42.13	22.79	32.46	60.00	39.23	49.62	56.79	50.77	53.78	45.00	36.27	40.64	50.98	37.26	44.12
2	56.79	33.21	45.00	50.77	36.27	43.52	56.79	39.23	48.01	63.44	45.00	54.22	56.95	38.43	47.69
3	39.23	22.79	31.01	68.61	33.21	50.91	53.73	26.56	40.14	54.76	22.79	38.78	54.08	26.34	40.21
4	56.79	30.00	43.40	67.21	26.56	46.88	60.00	36.27	48.14	53.73	30.00	41.86	59.43	30.71	45.07
5	30.00	33.21	31.60	45.00	42.13	43.56	47.87	53.73	50.80	47.87	47.87	47.87	42.68	44.24	43.46
Average	44.99	28.40	36.69	58.32	35.48	46.90	55.04	41.31	48.17	52.96	36.39	44.67	52.83	35.39	44.11

	Sx^2	DF	M_s	F
Total	6377.1980	39		
Companies (C)	3038.3976	1	3038.3976	169.679**
Machines (M)	796.0864	3	265.3621	14.819**
Positions (P)	234.8221	4	58.7055	3.278*
$C\times M$	111.0565	3	37.0188	2.067
$C\times P$	1218.4119	4	304.6029	17.011**
$M\times P$	763.5436	12	63.6286	3.553*
$C\times M\times P$	214.8799	12	17.9067	

* Significant. ** Highly significant.

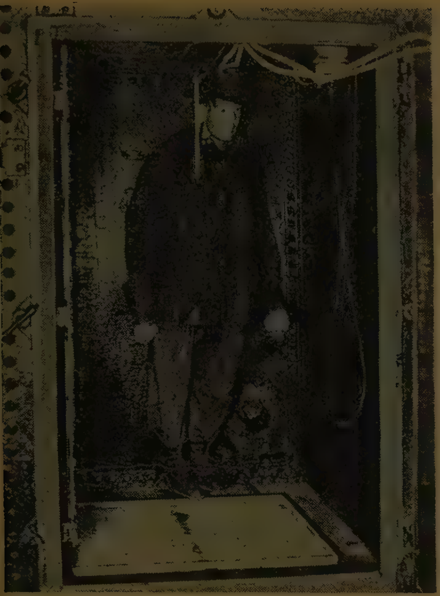

Figure 7. Explosion-proof electric-equipment testing chamber

The net result in this instance demonstrated a consistent difference in quality between the two products and a more marked effect on one product for one particular mounting location although a consistently more severe test condition for both products for this same test location on the machine.

Arc-Resistance Analysis. A more complex application of the statistical-analysis procedure shown in Table I involves second-, third-, fourth-, and fifth-order interactions where interactions are defined broadly as the number of result changing forces that are working simultaneously to produce a composite end result. This is illustrated in Table II.

This procedure applies not only to research but to repetitive test problems in standardization.

Arc Test. Figure 5 shows the test apparatus employed to obtain the results for the statistical analysis. The arc resistance of a material or the resistance of a material to tracking is very important in many applications in electric equipment. Numerous methods have been proposed and finally one has been adopted by general usage. This method consists of an arc of ten milliamperes from a 15-kv transformer between electrodes 0.32 inch apart. The arc is applied intermittently to the surface of the material until a conducting path is formed on the material as indicated by the transfer of the arc from the air to the material.

Although this method has been in general use for 10 to 15 years, a recent test in a number of laboratories on identical materials indicated that the variation in results between laboratories was greater than the variation between materials.

Closer study of the method used in the various laboratories disclosed a number of factors which may contribute to the lack of reproducibility and the significance of this test procedure.

Plated Plastic. Figure 6, when considered in connection with Figure 5 depicting arc resistance of plastics, probably appears in the light of a paradox. The rods shown are insulating plastics with copper- and silver-plated films made up experimentally to determine the possibilities existing in using a molded insulation shape such as an instrument case with the shielding as an integral part of the case. It also may have possibilities as a reflecting surface in lighting fixtures. This latter was given some consideration during the critical-supply status of metals. This plating of thermoplastic materials (those softening when heated) is more simple than for the samples illustrated which are molded from the thermosetting resins.

Flame Test. The flame-test method for testing flame resistance of dielectrics has been developed in order to evaluate performance characteristics accurately. This particular test is very familiar to engineers engaged in the design of cable. It is based on the measured and constant electrical input to the heater coil which, in combination with the sparking arrangement, will provide information showing time for ignition of the cable sheath and burning time. In a truly flameproof cable this burning time represents only that period for which the thermal capacity of the cable sample will cause combustible gases to be given off and ignited after removal of the heating source. In other words, the higher temperature necessary for burning the gases is maintained for a time by the thermal capacity or stored heat of the test sample and not by a sample that supports combustion.

Explosion-Proof Electric-Equipment Testing. Figure 7 does not represent an execution chamber as it might appear at first sight. The figure is a dummy used in conjunction with an investigation to determine, in the installation of electric equipment in shipboard spaces where gasoline or other explosive vapors are present, whether a safe level could be found where the hazard did not exist. The dummy was kept at body temperature and was moved about the compartment to simulate movement of shipboard personnel. The effect on the explosive vapor level or the explosive vapor–air concentration then was measured at different heights. The tests were conducted at the Navy portion of the Engineering Experiment Station in Pittsburgh, Pa. In addition to this specific work the shipboard requirements for explosion-proof electric equipment have been developed as a result of research work at this laboratory. Such explosion-proof equipment in itself represents quite a broad field of investigation.

A partial birdseye view, or, if you will, one facet of a many-sided picture has been presented. This view should indicate, rather than actually locate, the parameters of electrical naval research. There

Table II. Arc-Resistance Analysis

		C_1						C_2					
		E_1			E_2			E_1			E_2		
		H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3
B_1 F_1	T_1	— — —											
	T_2	— — —											
B_1 F_2	T_1												
	T_2												
B_2 F_1	T_1												
	T_2												
B_2 F_2	T_1												
	T_2												

Five Main Effects	Ten First-Order Interactions	Ten Second-Order Interactions	Five Third-Order Interactions	One Fourth-Order Interaction
(C)	C×E E×B	C×E×H C×B×F	C×E×H×B	C×E×H×B×F
(E)	C×H E×F	C×E×B E×H×B	C×E×H×F	
(H)	C×B H×B	C×E×F E×B×F	C×E×B×F	
(B)	C×F H×F	C×H×B E×H×F	C×H×B×F	
(F)	E×H B×F	C×H×F H×B×F	E×H×B×F	

(C) Electrode condition cleaned or uncleaned.
(E) Electrode mechanical condition.
(H) Humidity condition.
(B) Type of binder.
(F) Type of filler.

are many aspects of the work that have not even been approached, and this is especially true of that portion maintained in the confidential or secret classification for security reasons. A very few of the many important and interesting things that form a part of the total picture are indicated in the five following examples:

1. The design and installation of a short-circuit test station which will make available current of 100,000 amperes three-phase alternating current, 450 volts or 50,000 amperes, 250 volts direct current. The approximate maximum timing period for each is eight cycles.

2. The subject of electronics which is a field within itself and is far beyond the scope of the present discussion.

3. The study of electric-propulsion systems for different types of warcraft and representative of one of the phases of electrical research having a broad engineering aspect.

4. A program for the preservation of inactive ships which is a most significant phase of naval research with particular reference to the optimum conditioning that should be maintained in order to prevent deterioration in quality of the electrical insulation. This preservation program is a major postwar consideration.

5. The problems arising out of loss of sources of supply for raw materials used in electrical applications, such as tin, rubber, nickel, and the limited quantities of home materials available, where a shortage is created by wartime increase in amounts required for other than electrical purposes. This factor imposed a severe burden on, and at the same time, stimulated electrical research in the Navy.

This article will have served its purpose if it is thought provocative to the extent that it conveys an idea of the scope and magnitude of problems encountered in naval research. The picture as presented is admittedly only a small part or one facet of a many-sided total and is necessarily a viewpoint that primarily relates to shipboard material. It has, however, been the objective throughout the presentation to express it in the common language of research which links together the members of the electrical-engineering profession regardless of their immediate field of application.

Fog Dispersal at British Airfield

A squadron of bombers took off from an airfield in England in December 1944 when the visibility had been cut to about 100 yards by a fog blanket. Returning from a successful mission, they landed safely when the visibility of the area was only 50 yards. One of aviation's worst enemies—fog—had been demonstrated to be impotent. How this seemingly impossible feat was accomplished is told by A. C. Hartley, technical director, Britain's Petroleum Warfare Department, in the September 1945 issue of *Civil Engineering*. Actually, the runway is converted into a huge brazier whose heat lifts fog in the area over and adjacent to the landing strip.

This operation, developed by British engineers, meteorologists, scientists, and pilots, is called "Fido," standing for fog investigation dispersal operations. In a race against time for the lives of Allied pilots, many experts were brought together, and charged with finding a solution to the perplexing problem, sparing no cost. The objective was to clear of fog a space 1,000 yards long by 150 feet wide to a height of 100 feet, 500 yards of the cleared space to be in the approach and 500 yards on the runway.

Research and experiment went on simultaneously. The methods considered included the use of supersonic waves, electrical discharges, absorption of moisture by chemicals, drying by refrigeration, and outdoor air-conditioning apparatus. From the outset, however, the dispersal of fog by heat promised the greatest success. Fog chambers were erected and large-scale heat-producing installations assembled in fog-ridden districts while Royal Engineers constructed and manned a special mobile installation to be sent wherever fog was reported.

The first success came November 4, 1942, when on Moody Down, Hampshire, a fog of 50-yard visibility was cleared by petroleum burners in an area 200 yards square to a height of 80 feet. The same day an even denser fog was cleared at Staines, down wind of a line of braziers burning hundreds of tons of coke. Parallel experiments proved petroleum more successful than coke, though it produced more smoke. It lit up quicker, involved less manpower, and easily could be piped to the site by linking the countrywide network of pipe lines.

By January 1943, experimental large-scale runways had been constructed to which the Fido team hastened whenever they received special fog warnings—usually in the small hours of the morning. It was discovered that if the heat of the atmosphere could be raised seven degrees Fahrenheit the fog disappeared. This heat is provided by a continuous line of petroleum burners installed parallel to, and some distance from, each side of the main runway. The height of the clearance depends upon the wind and the moisture content of the fog. In extreme conditions, such as cloud or sea fog and high winds, it is difficult to get good clearances up to 100 feet, but in calm weather with radiation, fog clearances of more than 500 feet have been obtained.

Standard fog-dispersal installation consists of three main portions—burner lights, pumping and distribution, and storage. On the initial light-up, much smoke is created, but this quickly clears as the petroleum vaporizes. In normal conditions, the fog can be cleared in ten minutes. It has been cleared in six minutes. When intersecting runways are crossed, a burner pipe sunk flush with the ground is necessary to avoid obstructing the aircraft. This is supplied by a separate vaporizing unit. The main fuel-handling pumps are six gasoline-engine-driven centrifugal pumps connected to the supply main from the storage tanks. The petroleum is stored in steel tanks. The installation is manned by one Royal Air Force sergeant, three corporals, and 17 aircraftsmen. It is estimated that "Fido" used up 100,000 tons of gasoline in two and one half years—6,000 gallons per aircraft landed.

The first experimental operational installation was erected on a Pathfinder airfield in February 1943, though it was not tested out in the fog until July 17, 1943, when visibility fell to between 100 and 200 yards. Fido restored full visibility on the runways for 1,300 yards. An aircraft took off and landed four times, and Fido's future was assured. It was being established on a number of airfields in eastern and southern England, including the Suffolk rescue station, where hundreds of lame and disabled planes, American as well as British, were brought in.

After months of experiment, Fido was brought into operational use on November 19, 1943. On that day, four Halifax bombers landed successfully on returning from the Ruhr, when the surrounding visibility of the airfield was only 100 yards, because ten minutes after Fido had been lit, visibility on the runway increased to the equivalent of from two to four miles. Since then more than 2,500 Allied aircraft have landed safely—often in dense fog—with crews of more than 10,000 airmen.

About 500 men composed the Fido team, including scientists, a departmental staff of about 50 Royal Engineers, who had the distinction of making the first fog clearance in Hampshire, about 40 Royal Air Force ground staff, engineers, and contractors' men. The Bomber Command loaned experienced pilots and meteorologists.

Statistical Methods in Quality Control

V. Variations to Be Expected in Sampling

This article discusses the chance variations to be expected in observed averages, standard deviations, and so forth, when the quality of a product is measured by samples.

WHENEVER we take a random sample of articles from a batch of product and measure them for some quality characteristic, we do not expect the results to be exactly the same as for the entire batch. The smaller the sample, the more widely may the observed results differ from the true. It can be shown that the magnitude of expected sampling errors (differences between sample values and true values) varies inversely as the square root of the number of articles in the sample.

Take as a particular example the plate current of a vacuum tube. In preparing to manufacture the tube, the producer sets up a production process involving materials, machines, and workmen. There results a complex system of causes, each element contributing to the variations that will be observed in the measured values of plate current for the individual tubes. If each of the causes of variation continues to have the same probability of contributing a given effect, the quality with respect to plate current may be said to be controlled in the technical sense. The cumulative effect may be represented by an overall frequency distribution such as is shown in Figure 1.

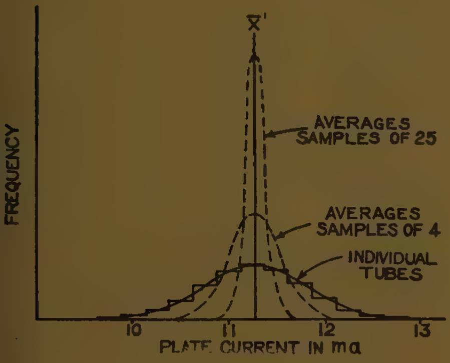

Figure 1. The effect of sample size on the distribution of sample averages

As indicated in an earlier article of this series, this frequency distribution may be regarded as a statistical representation of the entire production process and may be described by such statistics as the average, $\bar{X}'$, the standard deviation, σ', and the fraction defective, p', the proportion falling outside the specified limits. It is always helpful to keep in mind that behind the scenes there exists some such frequency distribution with some definite set of statistics ($\bar{X}'$, σ', p') which represent the process at any one time.

Suppose we had such an idealized controlled process. Then, so long as the process remains the same, we can predict on a probability basis just how the results of, say, samples of 100 tubes, samples of 25 tubes, or samples of 4 tubes would behave; how these results would differ from the corresponding true distribution curve.

To do this, we find it convenient to express the collective plate current measurements for a sample of n tubes in terms of these same simple statistics: the average, $\bar{X}$, standard deviation, σ, or the fraction, p, of the total observations that fall outside the specification limits.

The solid curve of Figure 1 represents the distribution of plate current values for individual tubes, and the dotted curves indicate the distributions to be expected for averages of samples of 4 and samples of 25. From this it is seen that the larger the sample, the more closely may the observed sample average be expected to approximate the true average, $\bar{X}'$, of the process, the spread being inversely proportional to the square root of he sample size.

This, perhaps, may be seen more clearly from Figure 2, in which the distribution is tipped over on its side and the measurement scale drawn vertically. In Figure 2 we consider successive tubes or successive samples of tubes coming from such a process. For successive individual tubes practically all of the measured values may be expected to fall within the band $\bar{X}'\pm3\sigma'$. In like manner the observed values of sample averages ($\bar{X}$), for successive samples of n tubes will fluctuate around the *true* value for the distribution curve representing the process. The figure indicates, for example, the range within which *practically all* (theoretically 99.7 per cent) of the averages for samples of stated size will fall under these controlled conditions. The dotted lines shown on the figure are determined from the relation

Limits for sample averages ($\bar{X}$) =

$$\bar{X}'+3\frac{\sigma'}{\sqrt{n}}$$

We can say, for example, "*If* the process is controlled in the foregoing sense, and has an average, $\bar{X}'$, and a standard deviation, σ', then *practically all* the individual observed values will fall within the band $\bar{X}'+3\sigma'$, *practically all* averages of random samples of size four will fall within a band only one half as wide, and for samples of 25 only one fifth as wide.

Similar charts could be drawn for sample standard deviations (σ) and for sample values of fraction defective, (p), in which case

Limits for sample standard deviations (σ) =

$$c_2\sigma'\pm3\frac{\sigma'}{\sqrt{2n}}$$

where c_2 is a constant dependent on sample size:

$c_2=0.798$ for $n=4$
$=0.970$ for $n=25$
$=1.0$ for all practical purposes for n greater than 25

Limits for sample fraction defective (p) =

$$p'\pm3\sqrt{\frac{p'(1-p')}{n}}$$

This gives a rather general law of sampling, namely, that the variation of sample value of $\bar{X}$, σ, and p is inversely proportional to the square root of the sample size, n.

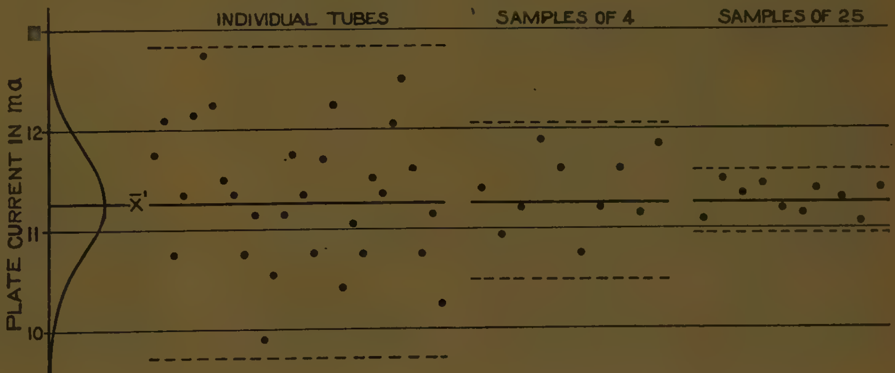

Figure 2. Variations in individual values and in sample averages

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One of a series of articles prepared in the AIEE subcommittee on educational activities and sponsored by the AIEE subcommittee on statistical methods.

Personnel of the AIEE subcommittee on educational activities: J. Manuele, H. F. Dodge, A. I. Peterson, and R. E. Wareham.

All of this represents ideal conditions. It assumes a controlled process, but, at the same time, it does provide a basis that is useful in setting up criteria in reference to the following:

1. For judging the degree of control or stability of a process.

2. For controlling the process through frequent periodic samplings.

The dotted lines shown in Figure 2 are similar to control limits of control charts that are to be discussed in subsequent articles. They are limits within which "practically all" of the plotted points should fall when everything is running all right. Accordingly, when the plotted point for a sample falls outside the dotted lines, this may be taken as an indication of a findable cause of a change in process and can be used as a criterion for some action such, for example, as stopping the machine when the control chart is being used for process control.

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Electrical Essays for Recreation

The following essays are presented for the recreation of the reader. The author's challenge to the reader is: Can you find the error in the reasoning accompanying the various examples?

MOTOR WITH NO FRAME REACTIONS

Figure 1 shows a bar magnet with a wire placed perpendicular to the magnet and a distance from the *N* pole. If the wire carries a current *i* in the direction indicated by the arrow there will be a force on the wire out of the page. The reaction on the *N* pole will be into the page. These forces produce a couple and if the wire is bent as shown and placed in bearings the U-shaped wire will tend to turn toward the reader and the magnet will tend to move away from the reader. Therefore if the magnet is fastened to the wire, say by some plastic material, the combination will rotate and supply a load.

An application for this type of motor would be the driving motor for a torpedo. The torpedo then could be fitted with only one propeller with no tendency for the propeller to remain stationary and let the torpedo rotate.

PARALLEL CIRCUIT PARADOX

Consider the circuit of Figure 2. A one-ohm resistance is connected in series with a rectifier. A similar circuit is connected in parallel with the first so that the rectifiers will permit current through the circuit in both directions. If the total alternating current is adjusted to ten amperes then the current in each branch will be five amperes. If the drop in the rectifier is neglected the effective voltage across each parallel branch is five volts and therefore the total voltage is also five volts since each branch of a parallel circuit is subject to the total voltage.

However, during one half cycle the current is in one one-ohm resistor, and during the other half cycle the current is in the other one-ohm resistor. Therefore the circuit behaves as though the alternating current were in one 1-ohm resistor. Hence the total voltage is ten instead of the five obtained in the foregoing discussion.

A PERPETUAL-MOTION MACHINE

This machine depends for its action on what is known as *retarded potentials*. The idea may be illustrated in connection with the stars. The star Arcturus is 40 light years away. It is so far away that it takes 40 years for the light emitted by it to reach us. When we look at it we do not see it where it is now but where it was 40 years ago! Light waves and electric-field and magnetic-field disturbances are propagated with the same finite velocity, about 186,000 miles per second.

Consider a positive charge *q* and a negative charge $-q$ placed *r* meters apart, Figure 3a. The attraction of one to the other is given by the formula

$$F=\frac{q^2}{kr^2} \tag{1}$$

where *F* is in newtons, *q* in coulombs, *r* in meters, and *k* is the dielectric constant of the medium in meter-kilogram-second units.

Now suppose the negative charge is moving downward as indicated in Figure 3b. The negative charge is attracted to the positive charge by the force

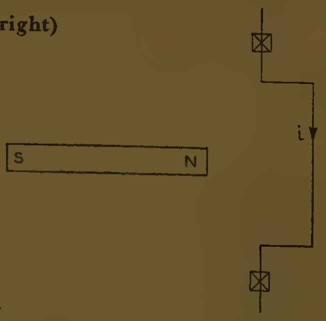
$$F=\frac{q^2}{kr^2} \tag{2}$$

exerted to the left. The positive charge is attracted by the force

$$F'=\frac{q^2}{kR^2} \tag{3}$$

directed to the point where the negative charge was an instant before, just as we see Arcturus where it was 40 years ago.

Figure 1 (right)



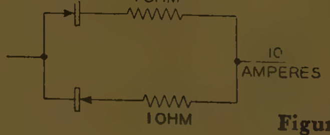


Figure 2 (left)

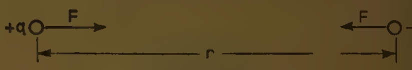


Figure 3a

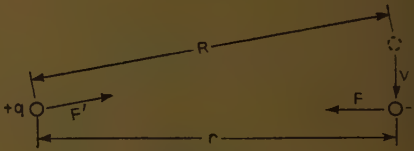


Figure 3b

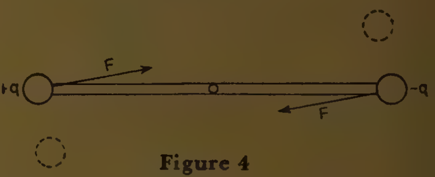


Figure 4

Now for the machine itself. Figure 4 shows the construction. It consists of two insulated electrodes placed at the ends of a bar that is pivoted at its middle. A charge is placed on each electrode, one positive, the other negative. The bar is rotated about the pivot. When the speed of rotation has been increased sufficiently the positive charge will be attracted toward the point where the negative charge was an instant before as shown by the arrow marked *F* in Figure 4. Similarly the negative charge is attracted toward the point where the positive charge was an instant before. The two forces shown in Figure 4 produce a couple in the direction of rotation and will overcome the friction of the pivot and enable us to obtain power from the shaft.

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25th Anniversary of Radiobroadcasting

History and events that led to the first scheduled broadcast of November 2, 1920, from the first established station, KDKA, Pittsburgh, with some interesting side lights, are discussed in this article on these two silver anniversaries.

"WILL ANYONE hearing this broadcast communicate with us, as we are anxious to know how far the broadcast is reaching and how it is being received." These words repeatedly came out of the air on the night of November 2, 1920—election night—interrupting the first scheduled broadcast made from the first established radio station, KDKA, Pittsburgh, Pa.

The chronology of events in the radio field since that fateful night reveals such wonderful achievements that it is difficult to believe that today's billion-dollar-a-year industry with a radio set for every two people in the United States, had its humble beginnings in an improvised shack atop one of the buildings of the then Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. The station could boast of no studio but had one room accommodating the transmitting equipment, a turntable for records, and a small staff of announcer, engineer, operator, and telephone-line handler.

Broadcasting began at six o'clock on that November night and continued until noon the following day, even though the election returns had been given as final the previous night when Candidate Cox had acknowledged defeat and conceded victory to Senator Harding. Throughout that stormy night, while the usual crowds stood before outdoor bulletin boards to see the returns, others were hearing the same returns in the comfort of their homes with crystal sets and earphones. In between announcement of returns music occasionally was injected.

The broadcast was a national sensation, acclaimed by newspapers all over the country. People telephoned for more news and less music. One report came from H. W. Irving, now transmitter supervisor at KDKA. Working as a Merchant Marine radio operator assigned to the United States Army transport, *Antigone,* he heard the program off the Virginia coast while en route with troops from Puerto Rico to New York.

But none of the comments sent in envisaged the future possibilities of this discovery nor could any seer of the 20's in his wildest flights of imagination have prophesied the developments that followed that broadcast, such as the extension of operation to higher and higher frequencies, the electronic television pickup or the development of the thermionic vacuum tube which eliminated the need of batteries and made possible operation of radio receivers from ordinary house current.

The construction of KDKA, begun only one month prior to the election, was entrusted to the late Frank Conrad (A '02, F '37) then assistant chief engineer of the Westinghouse Company and an enthusiastic radio amateur. The first KDKA license was issued October 27, 1920, and call letters were assigned from a roster maintained to provide identification for ships and shore stations, these being the only regular radio services then in operation under formal license by the Federal Government. Assisting Doctor Conrad in his work was his long-time friend and coworker, D. G. Little, former Kalamazoo, Mich., radio "ham" and at present consulting engineer in the Westinghouse industrial electronics division at Baltimore, Md. Mr. Little had been tinkering with vacuum-tube radio since 1910.

The story goes that Frank Conrad first had become interested in radio in 1915 when to settle a $5 bet on the accuracy of his $12 watch he had built a small wireless receiver to hear time signals from the Naval transmitter at Arlington, Va. Intrigued by his new hobby Doctor Conrad turned next to the construction of a transmitter which he installed on the second floor of a garage at the rear of his residence in Wilkinsburg, Pa. First official record of this station appeared in the August 1, 1916, edition of the *Radio Service Bulletin* issued monthly by the Bureau of Navigation of the United States Department of Commerce. Shortly thereafter security precautions, necessitated by the entry of the United States into World War I, brought about the cancellation of his station licensed as 8XK along with all amateur licenses. However, the ban was lifted in October 1919, and on October 17 of that year Doctor Conrad delighted "hams" with a phonograph-record concert. He had been bored with the monotony of radio messages discussing the kind of equipment being used, and began to substitute music for voice. The music delighted and amazed amateurs who became convinced that music really could be transmitted through space. So heavy was the demand for "more" that Doctor Conrad was forced to announce that, instead of complying with each individual request, he would "broadcast" records for two hours each Wednesday and Saturday evening. This is said to be the first recorded use of the word "broadcast" to describe a radio service. These broadcasts soon exhausted Doctor Conrad's supply of records and the Hamilton Music Store in Wilkinsburg offered a continuing supply of records if he would announce that the records could be purchased at that store. Thus sprang up the first radio advertiser.

Meanwhile interest in these broadcasts was becoming so widespread that a station

Figure 1. First broadcasting studio (1921) was in a tent

Figure 2. Transmitter used by Doctor Conrad in 1918

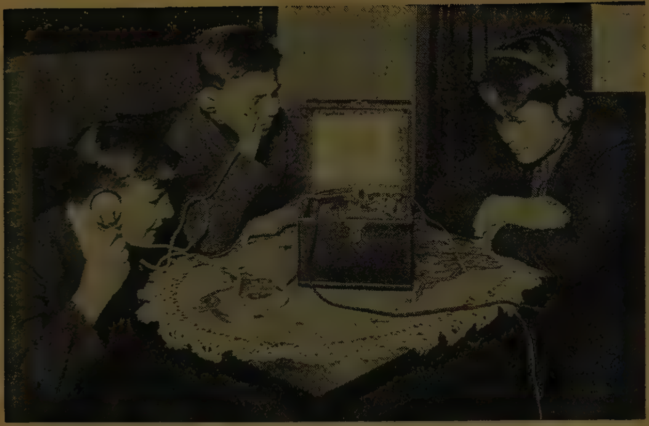


Figure 3. Early Westinghouse crystal-detector set

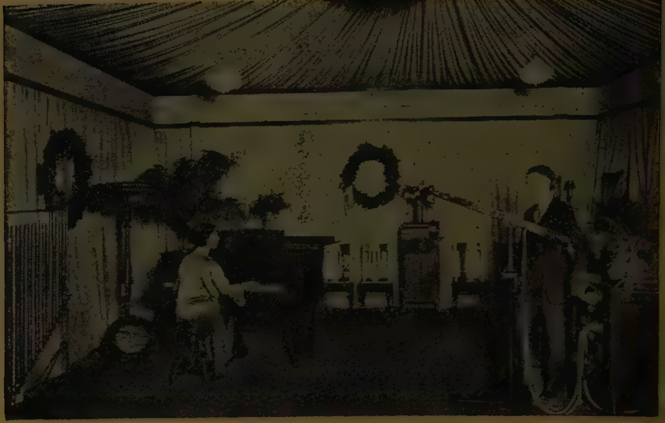


Figure 4. First real studio at KDKA installed in 1922

was authorized and a license application submitted October 16, 1920, and election night—only a little more than two weeks away—selected for the grand opening.

For the first six months of its existence KDKA was a radio station without a studio. There had been little need for one, since all programs were originated either as phonograph records played on turntables in the tiny transmitter penthouse atop the East Pittsburgh plant, or from churches, theaters, hotels, or other remote points. However, in May 1921, it was decided that the program structure should include live band and orchestral talent as well as recordings, and the services of several musical organizations of Westinghouse employees were secured. First programs were broadcast from an auditorium at the plant, but room resonance was so great that engineers immediately set about finding other facilities—a tent on a roof next to the transmitter penthouse was succeeded by an indoor studio at East Pittsburgh.

Many of those connected with the pioneer efforts of KDKA tell about the "growing pains" of the station in those early days of broadcasting. Some recall the whistle of a passing freight train which in the days of the tent studio became a regular feature at each evening's broadcast; others refer to the first Roger Babson's broadcast when it was discovered at the end that the transmitter had not been operating; and still others tell of the occasion when the angry words of a tenor not in good radio taste were summarily taken off the air.

These occurrences appear puerile in the light of the finished broadcasts of later days such as regular broadcasts of church services, important sports activities, market reports, news events, and subsequently all history-making events.

With broadcasting well on its way late in 1920 Doctor Conrad again concentrated on his amateur station at Wilkinsburg. Like all amateurs, his 8XK operated in the short-wave band as these stations were not rated of sufficient importance to warrant places in the highly regarded standard band. The short-wave band, on the other hand, was considered of little value, but Doctor Conrad did not share this sentiment. With considerable doubt in his mind about the generally accepted theories that the range of short waves definitely was limited Doctor Conrad began experiments in the spring of 1921. Tests revealed that short waves, reflected by the Heaviside layer and other ionized strata of the earth's rarified outer atmosphere, bounce back and forth between these layers and the earth and can be received only in those places where they strike the earth's surface. Shortly after and as a result of these researches the short-wave band became the most useful in the electromagnetic spectrum.

Another contribution to radio was Vladimir Zworykin's (M '22, F '45) demonstration of an electronic-beam television pickup which led to the iconoscope and "kinescope"—standard television equipment today.

The chronology of radiobroadcasting includes many interesting data and tells the story of many zealous experimenters and pioneers, some of whom are not living in the year 1945 to note the two silver anniversaries—one commemorating the world's first scheduled broadcast, November 2, 1920; the other marking establishment of KDKA, Pittsburgh, pioneer Westinghouse radio station from which that historic broadcast was made. Yet because of them—those living and those departed—who contributed no small part to the development of radio, cultural, educational, social, and amusement programs are being broadcast for the information and delectation of listeners scattered about the world. Its benefits in World War II can be stated best by the serviceman who "tuned" in on home programs, and in spirit, at least, joined the folks he left behind in an evening at the radio.

Communications in Italy

Communications networks in Italy have been restored so effectively by the United States Army Signal Corps that all sections of the country now are linked together by adequate cable and wire facilities for military and occupational purposes, according to a report to the Chief Signal Officer from the Mediterranean Theater. The prewar Italian civilian wire-communications network was both extensive and diversified but, as the result of German destruction, rehabilitation was required on both inside and outside plants before much of that system could be employed. Combining Italian and American equipment into an efficient and reliable network presented many technical problems.

In many areas military requirements were of such a nature and extent that existing civilian facilities were not adequate from either the standpoint of territory covered or the number and types of circuits available. Consequently, in addition to rehabilitation of the civilian system, the Signal Corps was required to construct local and long-line facilities for exclusive military use. This objective was accomplished by the addition of open-wire circuits on reconstructed civilian routes and the construction of strictly military open wire and cable routes.

Due to the swiftness of the Allied breakthrough in Northern Italy, much of the Italian civilian system and the German military network in those areas was captured before great destruction had been wrought through either battle damage or deliberate German demolition. Consequently, through the utilization of skilled German prisoners of war, supervised by Allied communication personnel, much of the network in Northern Italy was made available with a minimum of rehabilitation and new construction. Some German installations now are operated by German personnel under Allied supervision.

INSTITUTE ACTIVITIES

AIEE Officers to Be Nominated for 1946 Election

For the nomination of officers to be voted upon in the spring of 1946, the AIEE nominating committee will meet in New York, N. Y., in January 1946. The officers to be elected are: a president, a treasurer, three directors, and five vice-presidents, one from each of the odd-numbered geographical Districts. Fellows only are eligible for the office of president, and Members and Fellows for the offices of vice-president, director, and treasurer.

To guide this committee in performing its constituted task, suggestions from the membership are, of course, highly desirable. To be available for the consideration of the committee, all such suggestions must be received by the secretary of the committee at Institute headquarters, not later than December 15, 1945.

In accordance with the provisions in the constitution and bylaws, as amended during 1935 and quoted in the following paragraphs, actions relating to the organization of the nominating committee are now under way.

Constitution

28. There shall be constituted each year a nominating committee consisting of one representative of each geographical District, elected by its executive committee, and other members chosen by and from the board of directors not exceeding in number the number of geographical Districts; all to be selected when and as provided in the bylaws. The secretary of the Institute shall be the secretary of the nominating committee, without voting power.

29. The executive committee of each geographical District shall act as a nominating committee of the candidate for election as vice-president of that District, or for filling a vacancy in such office for an unexpired term, whenever a vacancy occurs.

30. The nominating committee shall receive such suggestions and proposals as any member or group of members may desire to offer, such suggestions being sent to the secretary of the committee.

The nominating committee shall name on or before January 31 of each year, one or more candidates for president, treasurer, and the proper number of directors, and shall include in its ticket such candidates for vice-presidents as have been named by the nominating committees of the respective geographical Districts, if received by the nominating committee when and as provided in the bylaws; otherwise the nominating committee shall nominate one or more candidates for vice-president(s) from the District(s) concerned.

Bylaws

Sec. 22. During September of each year, the secretary of the nominating committee shall notify the chairman of the executive committee of each geographical District that by December 15 of that year the executive committee of each district must select a member of that District to serve as a member of the nominating committee, and shall by December 15, notify the secretary of the nominating committee of the name of the member selected.

During September of each year, the secretary of the nominating committee shall notify the chairman of the executive committee of each geographical District in which there is or will be during the year a vacancy in the office of vice-president, that by December 15 of that year a nomination for a vice-president from that District, made by the District executive committee, must be in the hands of the secretary of the nominating committee.

Between October 1 and December 15 of each year, the board of directors shall choose 5 of its members to serve on the nominating committee and shall notify the secretary of that committee of the names so selected and shall also notify the 5 members selected.

The secretary of the nominating committee shall give the 15 members so selected not less than 10 days' notice of the first meeting of the committee, which shall be held not later than January 31. At this meeting, the committee shall elect a chairman and shall proceed to make up a ticket of nominees for the offices to be filled at the next election. All suggestions to be considered by the nominating committee must be received by the secretary of the committee by December 15. The nominations as made by the nominating committee shall be published in the March issue of *Electrical Engineering* (Journal of AIEE), or otherwise mailed to the Institute membership not later than the first week in March.

INDEPENDENT NOMINATIONS

Independent nominations may be made in accordance with provisions in article VI, section 31, of the constitution and section 23 of the bylaws, which are quoted below:

Constitution

31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the secretary when and as provided in the bylaws; such petitions for the nomination of vice-presidents shall be signed only by members within the District concerned.

Bylaws

Sec. 23. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with article VI, section 31 (constitution), must be received by the secretary of the nominating committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the nominating committee in accordance with article VI of the constitution and sent by the secretary to all qualified voters during the first week in April of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

(*Signed*) H. H. Henline,
Secretary

October 1, 1945

ABSTRACTS • • • •

The following abstracts of technical papers included in the fall program are in addition to those published in the September issue of *Electrical Engineering*, pages 330–33.

Statistical-Methods Applications

45-142—Statistical Methods in the Development of Apparatus Life Quality; *E. N. Ferrell. 20 cents.* Life tests on a new design of relay were so planned that the methods of statistical quality control could be used to separate assignable causes for variation from random causes for variation during life. The relays were inspected frequently at the beginning of the test and less frequently later. The results of these inspections were plotted in the form of control charts. From a study of points outside control limits, improvements were made in the design, the method of manufacture, and the method of test. From a study of the control limits and the number of points within them predictions were made as to the useful life to be expected. Simplified methods used in recording and analyzing the data and in establishing trends are described.

45-167—The Direct- and Quadrature-Axis Equivalent Circuits of the Synchronous Machine; *A. W. Rankin (A '38). 30 cents.* The equivalent circuits of the synchronous machine are needed for the determination of the subtransient reactances; of damping and synchronizing torques; the design of damper windings, and for many other problems of a design or operating nature. This paper presents more complete and more exact direct- and quadrature-axis equivalent circuits than have heretofore been available. Formulas for all the per-unit impedances needed by the equivalent circuits are derived and presented in this paper. These per-unit impedances are derived in a direct systematized form which eliminates the possibility of errors caused by inadvertent change of the base rotor currents. The permeance coefficients needed by the reactance formulas are determined by means of a gap reluctance expression whose accuracy is proved by comparison with similar coefficients evaluated from flux plots. Numerical values of these permeance coefficients are presented for a typical pole configuration.

Power Generation

45-168—Modern Practice in Power-Plant Auxiliary Equipment and Systems; *H. N. Muller, Jr. (M '43). 15 cents.* This paper hits high spots in the field of central-station auxiliary practice. Subjects are selected to include instances in which the design engineer may exercise judgment in choosing alternate items of apparatus, or in which specifications may influence apparatus design by emphasis on particular requirements. The paper includes discussions on several salient factors influencing motor design, a brief summary on present-day practice in the use of air circuit breakers and metal-clad switchgear, and a description of trends in power-distribution systems for central-station auxiliaries. Of interest is an analysis of the applicability of the secondary network system to auxiliary supply. A number of points that the design engineer should keep in mind when choosing the distribution system for power-plant auxiliaries are listed and discussed. The different forms that an auxiliary-system network may take are discussed with the object in mind of showing the extreme flexibility obtainable when this method of power supply to auxiliaries is adopted.

STANDARDS • • • •

Test Code for Synchronous Machines. A formally approved edition of the "Test Code for Synchronous Machines" now is available. This test code, issued in preliminary form in 1937, has been revised completely by the subcommittee on synchronous machines of the AIEE committee on electric machinery. It was approved in its final form by the board of directors on February 27, 1945. The code contains instructions for conducting the more generally applicable and acceptable tests to determine the performance characteristics of synchronous machines. It includes performance tests for synchronous generators, synchronous motors (larger than fractional horsepower), synchronous condensers, frequency changers, and rotary phase advancers. Copies of the code, number 503, may be obtained from AIEE headquarters, 33 West 39th Street, New York 18, N. Y., at a cost of 30 cents each, with the usual 50-per-cent discount to AIEE members on single copies.

Condensing Steam Turbine-Generators. A joint committee of AIEE and American Society of Mechanical Engineers on steam turbine-generators has developed preferred Standards and Standards specification data for large 3,600-rpm three-phase 60-cycle condensing steam turbine-generators (larger than 10,000-kw rated capacity). The joint committee prepared the preferred Standards and these have been approved formally by both the AIEE and the ASME. The Standards specification data for generators was prepared by the AIEE group of the joint committee and approved by the AIEE board of directors on February 27, 1945. The Standards and the specification data cover both air-cooled and hydrogen-cooled units. Copies of the pamphlet, numbers 601 and 602 containing both the Standards and the specifications, may be obtained from AIEE headquarters, 33 West 39th Street, New York 18, N. Y., at a cost of 60 cents each, with the usual 50-per-cent discount to AIEE members on single copies.

AIEE Standard No. 45A Withdrawn. AIEE pamphlet 45A, a modification of and supplement to AIEE Standard 45, "Recommended Practice for Electrical Installations on Shipboard," as issued in revised form January 1, 1944, and to apply during the "national emergency" only, has been withdrawn as obsolete by authorization of the AIEE committee on marine transportation. This action is based on the fact that the restrictions laid down by the War Production Board, which necessitated the issuance of 45A have been removed and, in addition, all vessels now being constructed are not limited for use during the national emergency. A new edition of pamphlet 45, including all items covered in 45A which it has been agreed should be recommended as standard construction, is now in course of publication. It should be available in late October.

A-C Power Circuit Breakers. By action of the American Standards Association as of May 16, 1945, an approved American Standard for "A-C Power Circuit Breakers" just has been made available in pamphlet form. This Standard, C37.4 to C37.9, originally was published in proposed form in January 1941 for trial use and study. On the basis of suggestions received during the trial period, principally from the protective devices committee of AIEE, the proposed Standards were brought to their present approved form. C37.4 to 9 supersedes AIEE publication 19, "A-C Power Circuit Breakers" issued in 1943 to provide for an interim standard. The new American Standard contains in the one pamphlet six sections as follows: "A-C Power Circuit Breakers," C37.4; "Methods for Determining the Rms Value of a Sinusoidal Current Wave and a Normal Frequency Recovery Voltage," C37.5; "Schedule of Preferred Ratings for Power-Circuit Breakers," C37.6; "Operating Duty for Standard and Reclosing Service," C37.7; "Rated Control Voltages," C37.8; and "Test Code for Power Circuit Breakers," C37.9. Copies can be obtained from AIEE headquarters, 33 West 39th Street, New York 18, N. Y. at $1.25 net (no discount to members).

SECTION • • • • • •

Montreal Electronics Group

As a result of a questionnaire and an indicated request for such activity, a technical group for the discussion and study of industrial electronic equipment has been initiated by the Montreal Section.

Two meetings have been held at which an agreement was reached on submitting a program for consideration. Discussions will include the following:

(*a*). Some atomic theory pertinent to industrial electronics.

(*b*). High-vacuum-tube construction and characteristics (with reference to atomic theories).

(*c*). High-vacuum-tube applications.

(*d*). High-vacuum-tube applications.

(*e*). Low-vacuum-tube construction and characteristics.

(*f*). Low-vacuum-tube applications.

(*g*). Rectifier transformers.

(*h*). Light-sensitive devices.

(*i*). High frequencies.

New York Lecture Courses

Autumn lecture courses are being resumed by the New York Section, AIEE. One feature of the curriculum is planned for engineers who want review of supplemental engineering training, and those preparing for professional license examination in New York and in New Jersey. The subjects covered are "motors," "radar," "induction and dielectric heating," and a symposium will be held on "servomechanisms."

PERSONAL • • • • •

William Percy Dobson (A '13, M '19, F '43) director of research, and head of the research and testing department, Hydro-Electric Power Commission of Canada, Toronto, Ontario, has been appointed 1945–46 chairman of the AIEE Standards committee of which he has been vice-chairman for the past year. He was born near Georgetown, Ontario, Canada, and was graduated from the University of Toronto in 1911 with a degree in electrical engineering. He joined the Toronto Hydro-Electric System after graduation and remained until 1912 when he was awarded a research fellowship by the engineering alumni association of the University of Toronto.

W. P. Dobson

He spent 18 months investigating transient electrical phenomena on the high-voltage power systems of the Hydro-Electric Power Commission of Ontario and the Toronto Power Company. In 1914 he joined the Hydro-Electric Power Commission as laboratory engineer. During the period when the commission's systems were expanding rapidly he was active in high-voltage transmission studies, and in the investigation of lightning phenomena, grounding, and protection of systems. He has been active in engineering standardization for more than 25 years, serving as member of the Standards committee of the AIEE for the past seven years. He was also vice-president of the AIEE Canada District for 1926–27. He is chairman of the Canadian Standards Association's committee on the Canadian electrical code. In 1919 he organized the approvals laboratory of the Hydro-Electric Power Commission for the testing and certification of electric materials and equipment for fire and accident hazards. Later the Canadian Standards Association assumed responsibility for this work on a national scale, and Mr. Dobson now acts as chairman of the approvals division. Mr. Dobson also serves on technical committees of the National Research Council of Canada, and the American Society for Testing Materials. He is also identified with the Ontario Association of Professional Engineers; Dominion Council of Professional Engineers; Engineering Institute of Canada; and was representative of the Dominion Council in the 1944 negotiations between the Dominion Government and the engineering and allied professions.

Dressel DeWitt Ewing (A '11, F '21) head of the school of electrical engineering, Purdue University, Lafayette, Ind., has been ap-

D. D. Ewing

pointed 1945–46 chairman of the AIEE committee on code of principles of professional conduct of which he has been a member since 1942. Professor Ewing was born in Vanlue, Ohio, and was graduated with a degree in electrical and mechanical engineering at Ohio Northern University in 1906. His first engineering work was as a cable testman with the Central Printing Telegraph and Telephone Company, Pittsburgh, Pa. Shortly thereafter he joined the engineering staff of Missouri Pacific Railway, St. Louis, Mo. In the autumn of 1907 he returned to Ohio Northern University as an instructor in electrical and mechanical engineering. In 1912 he became a graduate student and an assistant in electrical engineering at Purdue University. A year later he was appointed assistant professor of electric-railway engineering there and in various capacities has continued to serve the university since that time. In his early years as a teacher, Professor Ewing spent several summers with Westinghouse Electric and Manufacturing Company on railway electrification projects. Subsequently, he worked as a consultant on rate cases. Professor Ewing has acted as a director of research on projects for railway associations and manufacturing companies, and is the author of many articles on electric-railway and power problems. For many years he has served as a member of the power-transmission and distribution committee and of the way committee of the American Electric Railway Association, now the American Transit Association. He has served in various offices of the AIEE Central Indiana Section and has worked on the following committees: joint committee on welded rail joints, 1925–1933; electric welding, 1932–44; power transmission and distribution, 1936–42; and transportation (land transportation) 1936–42.

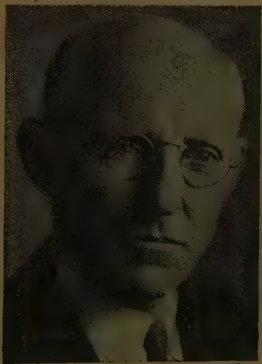
Morris Daniel Hooven (A '24, M '30, F '44) electrical engineer, electrical engineering department, Public Service Electric and Gas Company, Newark, N. J., has been appointed 1945–46 chairman of the AIEE technical-program committee of which he has been a member since 1942, and of the committee on award of Institute prizes. Mr. Hooven was born in Weatherly, Pa., May 30, 1897, and following studies at the Carnegie Institute of Technology, University of Vermont, and the Sheffield Scientific School, Yale University, was graduated from Bucknell University in 1920 with the degree of bachelor of science. In 1913 he was employed at Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and intermittently from 1914 to 1920 served as analyst and furnace chemist with the Carnegie Steel Company, Braddock, Pa. In World War I Mr. Hooven was in the United States Army Signal Corps. In 1920 he returned to the Westinghouse Company and a year later became manager of the radio department of the Robbins Electric Company, Pittsburgh, Pa. He entered the employ of Public Service Electric Company, Newark, N. J., in 1922 as one of the group engaged in the planning and design of the 132-kv system. He handled miscellaneous assignments in transmission and substation work receiving the title of assistant transmission and substation engineer, electrical-distribution department, in 1939. Since 1942 he has been electrical engineer, electrical-engineering department. Mr. Hooven has been active in the work of the New York Section and served as chairman in 1944–45. He has served on other industrial and professional bodies including Edison Electric Institute; Institute of Radio Engineers; Montclair Society of Engineers; and the American Standards Association.

Robert Ernest Doherty (A '16, M '27, F '39) president, Carnegie Institute of Technology, Pittsburgh, Pa., has been appointed chairman of the AIEE Edison Medal committee for 1945–46. Born January 22, 1885, in Clay City, Ill., Doctor Doherty received the degree of bachelor of science from the University of Illinois in 1909, that of master of science from Union College in 1920, and the honorary degrees of master of arts, 1931, Yale University, and doctor of laws from Tufts College and the University of Pittsburgh, 1936. He was employed as a student engineer by the General Electric Company, Schenectady, N. Y., in 1909, becoming a designing engineer in 1910 and a consulting engineer in 1923. In 1931 Doctor Doherty was appointed professor of electrical engineering at Yale University, New Haven, Conn., and in 1933 became dean of the school of engineering. He has been president of the Carnegie Institute since 1936. He has been active on various committees including the consultative committee on engineering, War Manpower Commission, 1942–43; and the advisory committee, Civil Advisory Council of the Office of Chief of Ordnance. In 1937 Doctor Doherty was the recipient of the Lamme Medal. He is a past-president of the Society for the Promotion of Engineering Education and a former chairman of the Engineers' Council for Professional Development.

Charles Frederick Wagner (A '20, M '27, F '40) manager, central-station engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been appointed chairman of the AIEE publication committee for 1945–46. Born in Pittsburgh, Pa., on March 20, 1895, Mr. Wagner was graduated from the Carnegie Institute of Technology in 1917 with a bachelor-of-science degree. His entire professional career has been with the Westinghouse Company which he joined in 1918 after a year of graduate study at the University of Chicago. During this time his work has included research and development of mercury-arc rectifiers and inverter systems; the study of transmission-system stability and short-circuit transients; and the analysis of machine performance and high-voltage lightning phenomena. In 1938 he was appointed consulting transmission engineer, and in 1941 manager of the central-station engineering department. Mr. Wagner is chairman of the general-systems subcommittee of the AIEE power-transmission and distribution committee of which he is a member, and is a member of the planning and co-ordination committee, and the transformer subcommittee of the electric-machinery committee. In 1938 he was awarded the best-paper prize in engineering practice and in 1943 the best-paper prize in theory and research as co-author of "Shielding of Substations."

Alexander Maxwell (A '03, M '12, F '37) director of engineering, Edison Electric Institute, New York, N. Y., has been appointed chairman of the AIEE board of examiners for 1945–46. He has been a member of the board since 1938. Mr. Maxwell was born in New York, N. Y., in 1878. In 1894 he became an assistant in the laboratory and testing department of the Westinghouse Electric and Manufacturing Company, Newark, N. J., and from 1895 to 1924 he was associated with the former New York (N. Y.) Edison Company and predecessor electric lighting companies as assistant superintendent of operation, in charge of the electrical and general laboratory and as engineer of distribution. Mr. Maxwell became an engineer for the National Electric Light Association, New York, in 1924 and continued with that organization until it was dissolved and succeeded by the Edison Electric Institute. He was made director of engineering for the latter company upon its formation in 1933. This position includes supervision of the organized activities of the electric-light and power-supply industry in the fields of engi-

M. D. Hooven



R. E. Doherty

C. F. Wagner

Alexander Maxwell

neering and operating and allied managerial activities. Mr. Maxwell is a member of the AIEE Standards committee and was first chairman of the domestic- and commercial-applications committee.

Robert Joseph Wiseman (A '16, M '20, F '27) chief engineer, The Okonite Company, Passaic, N. J., and Okonite-Callender Cable Company, has been appointed 1945–46 chairman of the AIEE committee on power transmission and distribution. Doctor Wiseman, born in July 1890 at Cambridge, Mass., was graduated from the Massachusetts Institute of Technology in 1912 with the degree of bachelor of science in electrical engineering. In 1915 he received the doctor-of-science degree from the same university. From 1915 until 1917 he was a member of the research staff of the Massachusetts Institute of Technology, Cambridge, and in the latter year accepted a position in the engineering department of the Western Union Telegraph Company, New York, N. Y. From 1918 until 1921 he served the National Conduit and Cable Company as wire and cable engineer. Then in 1921 he became research engineer of The Okonite Company. Seven years later he was made chief engineer. Also from 1924 to 1928 he served as research engineer of the Okonite-Callender Cable Company becoming chief engineer in 1928. Doctor Wiseman has been a member of several AIEE committees—research, 1931–39; instruments and measurements, 1937–39; application to marine work and marine transportation, 1937–43; board of examiners 1939–45; and power transmission and distribution, 1939–45. He is an associate member, Institution of Electrical Engineers of England; member, American Society for Testing Materials; member, committee on insulation of National Research Council; member, advisory committee on transmission and distribution, Edison Electric Institute; member, American Institute of Mining and Metallurgical Engineers; member Electrochemical Society; and past-president and secretary of Insulated Power Cable Engineers Association. He also has written papers on electrical insulation for electric-power cables.

Walter R. G. Baker (A '19, M '41) vice-president in charge of the electronics department, General Electric Company, Bridgeport, Conn., has been appointed 1945–46 chairman of the AIEE committee on electronics. Mr. Baker was born in Lockport, N. Y., on November 30, 1891, and was graduated from Union College from which he holds three degrees including the honorary degree of doctor of science. He joined the research laboratories of the General Electric Company, Schenectady, N. Y., in 1917, and worked on vacuum-tube transmitters and receivers. As the work increased a separate radio department was established, and he was made designing engineer in charge of transmitters. In 1924 his responsibility was further enlarged to include the design of all radio products, and two years later he was given complete charge of development, design, and production. Under his supervision some of the broadcast transmitters of the company were designed, and the South Schenectady developmental laboratory was designed and built. On the formation of the Radio Corporation of America and Victor Corporation in 1929, Doctor Baker went to Camden, N. J., to head the radio-engineering activities of the new organization. Within the year he was placed in charge of production, and later became general manager of the plant. In 1935 the General Electric Company transferred its radio-receiver activities to Bridgeport, and there Doctor Baker resumed his connections with the company, being named managing engineer in 1936, a post he held until May 1939 when he was elevated to the position of manager of the radio and television department. In 1941 he was presented a gold escutcheon plaque by the Institute of Radio Engineers in recognition of his work as chairman of the national television systems committee. He is a member of the National Electrical Manufacturers' Association, chairman of the Radio Technical Planning Board, fellow of the Institute of Radio Engineers, and director of the engineering department, Radio Manufacturers Association.

Raymond T. Henry (A '24, M '29, F '33) chief electrical engineer, engineering department, Buffalo (N. Y.) Niagara and Eastern Power Company, has been appointed chairman of the AIEE committee on the Charles LeGeyt Fortescue Fellowship for 1945–47. For further biographical details see *Electrical Engineering*, March 1944, page 110.

James Ferdinand Fairman (A '20, M '27, F '35) assistant vice-president, Consolidated Edison Company of New York (N. Y.), Inc., has been appointed chairman of the AIEE committee on planning and co-ordination. He has also served on the executive committee, 1944-45 and finance committee, 1944-45. For further biographical details see *Electrical Engineering*, March 1944, page 110.

Mark Eldredge (A '14, F '33) formerly chief, military and industrial unit, power division, Office of War Utilities, War Production Board, Washington, D. C., is now chief, electrical equipment section, Office of Surplus Property, Reconstruction Finance Corporation, Washington. Mr. Eldredge was born in Woodbury, N. J., and was graduated from Worcester Polytechnic Institute in 1906. He has been associated with many concerns, including General Electric Company, Schenectady, N. Y., United States Reclamation Service, Williston, N. Dak., and the Gilson Asphaltum Company, Dragon, Utah. From 1911 to 1913 he was professor of electrical engineering in Ewing College, Allahabad, India. During World War I he was commissioned a captain in the Quartermaster Corps of the United States Army. He returned to India in 1919 and was employed by the Ludlow Jute Company. In 1924 he became chief engineer for the Memphis (Tenn.) Power and Light Company. When the company was purchased by the City of Memphis in 1939, he became director, electric division, Memphis Light, Gas and Water Department. In 1940 Mr. Eldredge began devoting his energies to various war agencies. He has been active in AIEE affairs, and has served on many committees including the constitution and bylaws, of which he has been a member since 1941 and chairman since 1944, and planning and co-ordination committee, 1944–45. He was a vice-president 1935–37, and a director 1939–43.

Harry Sohon (A '28, M '43) formerly assistant professor of electrical engineering, Moore school of electrical engineering, University of Pennsylvania, Philadelphia, has been appointed advanced-development engineer with the Radio Corporation of America, Camden, N. J. He was born in New York, N. Y., and was graduated from Cornell University as electrical engineer in 1926, receiving the degrees of master of electrical engineering in 1930 and doctor of philosophy in 1932. Early in his career he served for a short period in the test department of General Electric Company, Schenectady, N. Y., and in 1930 he became instructor in electrical engineering at Cornell University, Ithaca, N. Y. After his appointment as assistant professor of electrical engineering there, and followed by a short period in the same capacity at the University of Connecticut, Storrs, Doctor Sohon accepted the position of assistant professor of electrical engineering at the University of Pennsylvania. He is the author of "Engineering Mathematics," and prepared the electrical essays recently published. (*EE, Aug. '45, p. 294; Oct. '45, p. 364.*)

R. J. Wiseman

R. T. Henry

J. F. Fairman

W. R. G. Baker

L. H. Hill (A '22, F '38) formerly vice-president in charge of industrial relations, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has resigned to become publisher of *Electrical World* and *Electrical Contracting*, published by McGraw-Hill Publishing Company, New York, N. Y. Mr. Hill was born in 1899 in Toms River, N. J., and was graduated from Cornell University with a degree in electrical engineering. From 1920 until 1922 he was an instructor in electrical engineering at the university, and in the latter year became design engineer, transformer-engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. In 1928 he was named manager, transformer division, American Brown Boveri Electric Corporation, Camden, N. J. He has been a member of the Allis-Chalmers organization since 1931 when the company took over the American Brown Boveri Company. Prior to becoming vice-president in charge of industrial relations, Mr. Hill was assistant manager of the electrical department. He holds approximately 40 patents on electric machinery and is the author of a text on transformers. Throughout World War II, Mr. Hill was active on the War Labor Board and was President Truman's first appointee as a full-industry member of the board. He is co-author of a recently published book "Management at the Bargaining Table."

B. K. Boulton (M '31) formerly superintendent of operation, Quebec Hydro-Power Commission, Beauharnois, Quebec, Canada, has been appointed president, Wartime Housing Limited. Mr. Boulton was born in Ottawa, Ontario, Canada, in 1903, and was graduated from McGill University with a degree of bachelor of science in electrical engineering in 1925. At first he was associated with the Quebec Development Company, working at one time as engineer in charge of construction of the transmission system for the Duke Price Power Company. In 1929 he joined the Beauharnois (Quebec) Construction Company and was put in charge of all electrical work in the construction and permanent electrical installation in the Beauharnois station. Mr. Boulton is a member of the Canadian Electrical Association, of which he is a past-chairman of the electrical equipment committee; the Engineering Institute of Canada; and the Corporation of Professional Engineers of Quebec.

Haraden Pratt (A '15, F '37) vice-president and chief engineer, Mackay Radio and Telegraph Company, Inc., New York, N. Y., has been elected vice-president and chief engineer of All-American Cable and Radio, Inc., and the Commercial Cable Company. He has also been elected chairman of the Radio Technical Planning Board. He received the bachelor-of-science degree in electrical engineering from the University of California, in 1914, and upon graduation became associated with the Marconi Wireless Telegraph Company of America, San Francisco, Calif. In 1915 Mr. Pratt became expert radio aid at the Mare Island (Calif.) Navy Yard, in 1918 he was associated with the bureau of steam engineering, Navy Department, Washington, D. C., and in 1920 left to become an engineer for the Federal Telegraph Company, Palo Alto, Calif. In 1927 he was named engineer in charge of the development of radio aids for air navigation for the Bureau of Standards, Department of Commerce, Washington, and a year later accepted the position of chief engineer of Mackay Radio and Telegraph Company, Inc. A past president of the Institute of Radio Engineers, in 1944 he was awarded a medal of honor for his work in the field of radio communications.

J. T. Barron (M '20, F '27) vice-president in charge of electric operation, Public Service Electric and Gas Company, Newark, N. J., has been elected a director of the Public Service Corporation of New Jersey. Mr. Barron was born in 1884 in Columbia, S. C., and was graduated from the University of South Carolina with the degree of bachelor of science in 1905. From that year until 1907 he was associated with the testing department of the General Electric Company, Schenectady N. Y. In 1907 he entered the service of the Public Service Electric and Gas Company, has been identified with the testing laboratory and the construction department, and has served as chief operator of the substations and generating stations in the central division and as superintendent of the central division. In 1926 he was made general manager of the electric department and and has been a vice-president of the company since 1935.

F. E. Harrell (A '26, F '40) formerly chief engineer, Reliance Electric and Engineering Company, Cleveland, Ohio, has been appointed general works manager of the company. Mr. Harrell joined the sales engineering department of the Reliance Company's Chicago (Ill.) office in 1924, after graduation from Purdue University. In 1927 he was transferred to general engineering in Cleveland, and in 1924 became assistant chief engineer. **W. R. Hough** (A '35, M '41) product development engineer, has been named chief engineer to succeed Mr. Harrell. Mr. Hough became associated with the company in 1929, following his graduation from the University of Michigan. Prior to his work on product development he served as junior engineer, chief draftsman, and a-c design engineer. Both Mr. Harrell and Mr. Hough are past chairmen of the AIEE Cleveland Section.

J. H. Lampe (A' 20, M '26) former dean of engineering of the University of Connecticut, Storrs, recently became dean of the school of engineering at the North Carolina State College, Raleigh. Doctor Lampe is a native of Baltimore, Md. He received the degrees of bachelor of science in 1918, master of electrical engineering in 1925, and doctor of engineering in 1931, all from Johns Hopkins University, Baltimore. After a period of service with the United States Army from 1918–19, he taught electrical engineering at Johns Hopkins University until 1938, when he became head of the department of electrical engineering at the University of Connecticut. He was promoted to dean of engineering there in 1940. His industrial connections have dealt with such problems as high-voltage cable investigations, electrolysis, magnetic tests, and electric-power generation and transmission.

H. A. Winne (A '16, F '45) vice-president in charge of engineering, General Electric Company, Schenectady, N. Y., has been appointed vice-president in charge of engineering policy for the entire company. Mr. Winne joined the General Electric Company as a student engineer in the testing department in 1910. After holding various positions he was elected vice-president in charge of apparatus-design engineering in 1941 and assumed the duties of manager of engineering in January 1945. **E. E. Johnson** (A '25, M '40) assistant engineer, aeronautics and marine-engineering division has been made engineering manager of the apparatus department to succeed Mr. Winne. Mr. Johnson has been with the General Electric Company since 1922.

C. L. Dawes (A '12, F '35) associate professor of electrical engineering, Harvard University, Cambridge, Mass., has been awarded the honorary degree of doctor of engineering by Northeastern University. Doctor Dawes was born in Somerville, Mass., and is a graduate of the Massachusetts Institute of Technology with the degree of bachelor of science in electrical engineering. There he served as assistant in electrical engineering from 1909–11, and from 1911–19 he was instructor at Harvard University and also at Massachusetts Institute of Technology. In 1919 he was appointed assistant professor of electrical engineering at Harvard University and in 1931 associate professor. Doctor Dawes is the author of many technical papers and books and has served on many AIEE committees.

H. F. Kingdon (A '26, M '38) works manager, Commonwealth Electric Corporation, Ltd., Welland, Ontario, Canada, has been appointed chief engineer and manager of the transformer department of the Eisler Engineering Company, Newark, N. J. Mr. Kingdon received his engineering degree from the University of Michigan in 1923. He entered the transformer engineering department of General Electric Company at Pittsfield, Mass., and in 1925 he was appointed chief transformer engineer of English Electric Company of Canada and assistant manager in 1929. Five years later he joined the Commonwealth Electric Corporation as chief transformer engineer and assistant manager and in 1937 he was made works manager.

C. A. Powel (M '20, F '41) junior past president AIEE, and manager, headquarters engineering departments of the Westinghouse Electric Corporation, East Pittsburgh, Pa., who is now on leave as chief of the electrical and radio branch of the Allied Control Commission, has received the Order of Merit from his company "for his unusual ability to recognize opportunities for the development and application of electrical equipment in the electrical power industry, for his skill in . . . executing plans to further them . . . and for his . . . promotion of broad engineering and educational activities on a national scale." The Order of Merit is the highest honor conferred on Westinghouse employees. Mr. Powel joined the company 26 years ago.

David Williams (A '23) lieutenant commander of the United States Naval Reserve, and on wartime leave as manager, electrical equipment purchases of the Consolidated Edison Company of New York, N. Y., Inc., has been named supply officer in command of the largest naval supply depot in New Guinea. Commander Williams was born in Leeds, England, in 1897. Before going to the Consolidated Edison Company in 1920 he had been associated with the Automatic Switch Company, New York, as draftsman, the Union Switch and Signal Company, Swissvale, Pa., and the Southern Pacific Railroad.

E. J. Thimme (A '27, M '29) assistant to the division superintendent, Passaic division, electric distribution department of the Public Service Electric and Gas Company, Paterson, N. J., has been made division superintendent in that division. Mr. Thimme started with the company in 1923 as a cadet engineer after his graduation from the Massachusetts Institute of Technology. In 1926 he was appointed engineer in the Passaic division, electric distribution department, and became division distribution engineer in that division in 1929. Seven years later he was made district superintendent, Passaic district, and when the Paterson and Passaic districts were consolidated in 1937, he was appointed assistant to the division superintendent.

F. A. Fleming (M '43) major in the Canadian Army and formerly in the test and engineering departments of the Canadian General Electric Company, Toronto and Peterboro, Ontario, Canada, recently has retired from the Army after serving six years as a technical staff officer. He has purchased an electrical engineering business in Ottawa, and will specialize in the sale and service of scientific and electrical instruments under the firm name of Sheppard Electrical Laboratories. Major Fleming was born in Toronto, Canada, and studied in the technical schools of Toronto and the School of Applied Science and Engineering at the University of Toronto.

H. M. Jalonack (A '20, M '36) sales manager, central station division, General Electric Company, Schenectady, N. Y., has been appointed assistant to manager, transformer division. Mr. Jalonack entered the company's test division following his graduation from Syracuse University in 1917. Two years later he joined the general office organization. After spending four years in Schenectady and Pittsfield, Mass., in 1923 he was transferred to New York, N. Y., as district transformer specialist and served in this capacity until 1935 when he returned to Pittsfield as assistant sales manager, of the distribution-transformer and feeder-regulator section. He became sales manager of that section in 1942.

C. A. Butcher (M '22, F '43) formerly manager of the Pacific Coast manufacturing and repair department of the Westinghouse Electric Corporation, Oakland, Calif., has been appointed assistant general manager of the Crocker-Wheeler division, Joshua Hendy Iron Works, Ampere, N. J. Mr. Butcher is a native of Des Moines, Iowa, and was graduated from the Iowa State College with the degree of bachelor of science in electrical engineering. Following his early electrical experience with the Des Moines City Railway Company, he joined the Westinghouse company and has served in several capacities.

G. H. Woodard (M '42) manager of the aviation gas turbine division of Westinghouse Electric Corporation, Philadelphia, Pa., has received the company's Order of Merit in recognition of his creative engineering in the development of new products. Mr. Woodard was born in Schenectady, N. Y., in 1906 and received his degree in mechanical engineering from Cornell University in 1928. At one time he was associated with the Ingersoll-Rand Company at Phillipsburg, N. J. He joined the Westinghouse company in 1936 at the time of the formation of the new products division. He became manager of the new products division in 1941.

D. R. Shoults (A '35, M '42) formerly engineer of the aviation division, General Electric Company, Schenectady, N. Y., has been appointed vice-president of the Bell Aircraft Corporation, Buffalo, N. Y. Mr. Shoults was born in Storms, Ohio, and was graduated from the University of Idaho in 1925 with the degree of bachelor of science in electrical engineering. In that year he became associated with the General Electric Company. He is the author of a number of technical papers, and was engaged in a study of superchargers when he left for London in 1941 on a Government mission. He has served on several AIEE committees.

C. F. Miller (A '41) formerly a member of the electrical engineering faculty of Johns Hopkins University, Baltimore, Md., has been appointed chief engineer of Price Brothers Company, Frederick, Md. Doctor Miller received his bachelor degree from the Johns Hopkins University in 1935 and the degree of doctor of engineering from the same university in 1942. He has undertaken extensive research and experimentation work during the present war emergency with various electronic applications.

H. W. Tenney (A '23, F '43) assistant to the vice-president in charge of the Pittsburgh, Pa., divisions of the Westinghouse Electric Corporation, has been awarded the Order of Merit, the highest recognition for achievement given by that corporation. Mr. Tenney was born in Leominster, Mass., and was graduated from the Worcester Polytechnic Institute in 1920 with a bachelor-of-science degree and in 1922 he received the degree of electrical engineer. Mr. Tenney has been with the Westinghouse Corporation since 1920. He has served on several AIEE committees.

J. W. Carpenter (M '35) president and general manager of the Texas Power and Light Company, Dallas, has received the honorary degree of doctor of engineering from Southern Methodist University. Doctor Carpenter has been associated with many utility companies in Texas including the Corsicana Gas and Electric Company, the Athens Power and Light Company, the Dallas Power and Light Company, and the Texas Power and Light Company. Of the last-mentioned he became president in 1927.

J. S. Malsbury (A '33, M '39) captain, Signal Corps, United States Army, has been promoted to the rank of major. Major Malsbury, a member of the Reserve Corps since 1927, was ordered to active duty in 1942, and was stationed at Fort Monmouth, N. J., until July 1944. Then ordered overseas, he was first assistant theater radio officer in India, and in February 1945 he was made theater radio officer stationed near Kunming, Yunnan Province, China.

E. C. Brown (A '26, M '43) formerly assistant to the manager of the Connecticut Valley Power Exchange, Hartford, has been named manager. Mr. Brown graduated from the Massachusetts Institute of Technology in 1924 with the bachelor-of-science degree in electrical engineering. In that year he became tester for the United Electric Light Company, Springfield, Mass., and in 1925 was employed by the Connecticut Valley Power Exchange as assistant to the manager.

K. W. Miller (A '23, M '29) formerly senior engineer, Commonwealth Edison Company, Chicago, Ill., and former director of research of the Utilities Research Commission, has been appointed chairman of electrical-engineering research at the Armour Research Foundation of Illinois Institute of Technology, Chicago. Mr. Miller has done extensive work with oil-filled cables, and in the field of reduction of sheath losses on single-conductor underground power cables.

C. W. Mayott (A '13, M '43) formerly power expert of the Office of War Utilities, War Production Board, Washington, D. C., has resumed his position on the technical staff of the Hartford (Conn.) Electric Light Company. Mr. Mayott was instrumental in co-ordinating southeastern electric power plants, and will remain in the capacity of consultant for the Office of War Utilities.

P. S. Millar (A '03, M '13) president, Electrical Testing Laboratories, Inc., New York, N. Y., has been awarded the 1945 gold medal of the Illuminating Engineering Society. Mr. Millar is the second recipient of the medal established in 1943 in recognition of meritorious achievement which has conspicuously furthered the profession, art, or knowledge of illuminating engineering.

A. M. Musgrove, Jr. (M '37, F '45) lieutenant colonel, Corps of Engineers, United States Army, who is serving as chief engineer, utilities division, Camp Shanks, N. Y., has been awarded a certificate of commendation for his suggestion providing emergency lights at the exits of all post theaters in the event of failure of electric power.

H. O. Anderson (A '27) general sales manager, Rockbestos Products Corporation, New Haven, Conn., has been elected vice-president in charge of sales of that corporation. Mr. Anderson joined the corporation in 1927 to direct the sales, after being an agent in Boston, Mass., for Schweitzer and Conrad, Inc., Chicago, Ill.

J. L. Davison (A '43) on loan to the general engineering department, Aluminum Company of Canada, Montreal, Quebec, from

1937 until 1945, has returned to the Canadian Comstock Company, Ltd., Montreal, and has been appointed chief engineer.

F. M. Ogler (A '44) Philadelphia (Pa.) district manager, Trumbull Electric Manufacturing Company, has been appointed district manager of the Atlantic district, which now includes Maryland, Virginia, and the District of Columbia.

J. G. Glassco (A '03, F '28) retired general manager of the Winnipeg Hydro-Electric System, Manitoba, Canada, has been elected to honorary life membership in the Manitoba Electrical Association.

OBITUARY • • • • •

John Somerville Highfield (F '42) consulting engineer, Highfield and Roger Smith, London, England, died August 15, 1945. Mr. Highfield was born in Cheshire, England, November 28, 1871, and received his education at King's College. He had a wealth of electrical experience having been associated with many enterprises including: Central Electricity Board; Borough of Dover Electricity Department; Cambridge Electric Supply Company, Ltd.; Charing Cross, West End and City Electrical Supply Company; South Wales Electric Power Company; Brompton and Kensington Electric Supply Company, Ltd.; Metropolitan Electric Supply Company; Edmundsons Electricity Corporation, Ltd.; Cornwall Electric Power Company, Ltd.; Imperial Continental Gas Association; Compagnie Continentale du Gaz; and the South Wales Aluminum Company, Ltd. Mr. Highfield's accomplishments were many. He designed and set up the first testing department for the Chloride Electrical Storage Company; supervised the erection of the power station at Stafford; invented the Highfield automatic reversible booster for controlling batteries; designed and constructed a power station, tramway and supply systems at St. Helen's, Lancashire. He made many addresses before professional societies, and was the author of many papers. His patent specification on "Improvements Relating to Pressure Relief Devices for Transformer Tanks and Like Containers" was accepted September 9, 1942. He was director, Central London Electricity, and of the London Power Company; past-president, Institution of Electrical Engineers, London, and past vice-president, Royal Institution of Great Britain.

Adolphus Mansfield Dudley (A '08, M '10, F '13) retired engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa., died on August 16, 1945. Mr. Dudley was born in Cincinnati, Ohio, February 14, 1877, and received the bachelor-of-science degree in engineering in 1902 and the degree of electrical engineer in 1931 from the University of Michigan. Two years later he received the master-of-science degree from the University of Pittsburgh. Mr. Dudley began his professional career in 1902 as an erecting engineer, and two years later joined the Westinghouse Corporation. He successively held positions as control engineer; design engineer; commercial engineer; section engineer; engineering manager; engineering supervisor of development; manager of development engineering; marine application engineer; and engineering representative in the patent department. He retired early in 1944. He was author of "Connecting Induction Motors" and "Induction Motor Practice," and contributed the section on electric motors in the current Encyclopedia Brittanica. Some of his educational work was accomplished for the Engineers Council for Professional Development in its program of inspecting and accrediting schools of engineering. For three years Mr. Dudley was a member of the council of the Society for the Promotion of Engineering Education. In 1940 he was awarded the honorary degree of doctor of engineering by the University of Michigan for his contributions to professional engineering.

Max L. Kahn (A '20) chief engineer, General Electric Company, Ltd., Witton Works, Birmingham, England, died July 25, 1945. Doctor Kahn was born in Mannheim, Germany, in 1877, and subsequently became a naturalized British subject. He was educated at Karlsruhe University and was awarded his doctorate in 1902 for original work upon the characteristics of the contact resistance of carbon brushes. Early in his career he was associated with Brown Boveri and Company, Ltd., of Mannheim, and in 1904 was appointed chief designer of the Branch Engineering Company. Thence he proceeded to Witton as chief designer, succeeding to the post of chief engineer in 1933. During the 32 years he served the General Electric Company he was closely associated with the developments in electric machinery and was responsible for the design of some of the largest turbogenerators manufactured. He was a member of the Institution of Electrical Engineers, and collaborated with E. Arnold and J. E. LaCour in the preparation of a series of textbooks in seven volumes covering the design and construction of electric machinery.

Henry Girdlestone Acres (A '08, M '13) president, H. G. Acres and Company, consulting engineers, Niagara Falls, Ontario, Canada, died September 4, 1945. Born in Paris, Ontario, May 1, 1880, he was graduated from the University of Toronto with the class of 1903, and in 1924 was made doctor of science by the same university. From August 1903, to June 1905 he was assistant mechanical engineer for the Canadian Niagara Power Company, Ontario, and then did some special design and tunnel work for the Arizona Copper Company, Clifton. In September 1905 Doctor Acres became associated with the Hydro-Electric Power Commission of Ontario first as hydraulic engineer and later as assistant engineer, and at various periods served as its consultant. One of his accomplishments was designing the Shipshaw development of the Aluminum Company of Canada, Arvida, Quebec, and designing and supervising the Chippawa–Queenston development of the Hydro-Electric Power Commission of Ontario.

John M. Davis (A '34) transmission engineer, Indiana Bell Telephone Company, Indianapolis, and more recently a colonel in the Army of the United States, died August 13, 1945. Colonel Davis was born in Owen County, Ind., in 1905, and received a bachelor-of-science degree in electrical engineering from Purdue University in 1926. During 1926–27 he was a student engineer with the Indiana Bell Telephone Company, and for the next three years served as assistant engineer. In 1930 he took over the duties of toll-transmission engineer in charge of studies, field tests, and surveys on toll-plant transmission problems, engineering studies on radio, and special services. Colonel Davis entered on active military service in 1941 and went overseas in 1944, returning to the United States several months ago. While serving on Leyte Island he became ill. It was at that time he was awarded the Bronze Star Medal for his outstanding and difficult assignments for the Signal Corps.

MEMBERSHIP • • •

Recommended for Transfer

The board of examiners, at its meeting of September 20, 1945, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the secretary of the Institute.

To Grade of Fellow

Berberich, L. J., section engr., Westinghouse Research Labs., E. Pittsburgh, Pa.
Brown, F. S., elec. engr., Duquesne Light Co., Pittsburgh, Pa.
Crary, S. B., engr., analytical div., General Electric Co., Schenectady, N. Y.
Drake, C. W., asst. mgr., ind. engg. dept., Westinghouse Electric Corp., E. Pittsburgh, Pa.
Godsey, F. W., Jr., mgr., new products div., Westinghouse Electric Corp., Pittsburgh, Pa.
Hansson, E., trans. engr., Pennsylvania Water & Pr. Co., Baltimore, Md.
Heintz, R. M., vice-pres. & secy., Jack & Heintz, Inc., Cleveland, Ohio.
Johnson, R. E., chief elec. engr., Barber-Colman Co., Rockford, Ill.
Kilgore, L. A., mgr., trans. & gen. div., Westinghouse Electric Corp., E. Pittsburgh, Pa.
Loughridge, C. H., cons. elec. engr., The Arcade, Cleveland, Ohio.
Monteith, A. C., asst. mgr., engg. depts., Westinghouse Electric Corp., E. Pittsburgh, Pa.
Penney, G. W., mgr., electro-physics dept., Westinghouse Electric Corp., E. Pittsburgh, Pa.
Pinder, K., sr. elec. engr., E. I. duPont de Nemours & Co., Wilmington, Del.
Renshaw, D. E., engr., Westinghouse Electric Corp., E. Pittsburgh, Pa.
Strang, H. E., asst. to vice-pres., General Electric Co., Schenectady, N. Y.
Umansky, L. A., asst. mgr., ind. engr. div., General Electric Co., Schenectady, N. Y.
Van Sickle, R. C., design engr., Westinghouse Electric Corp., E. Pittsburgh, Pa.
Warner, R. G., vice-pres., United Illuminating Co., New Haven, Conn.

18 to grade of Fellow

To Grade of Member

Allum, J. A. C., mgr. director, Allum Electrical Co., Ltd., Auckland, N. Z.
Becker, H. E., supervisor, Westinghouse Electric Corp., San Francisco, Calif.
Bennon, S., elec. engr., Westinghouse Electric Corp., Sharon, Pa.
Booth, J. D., sect. engr., Westinghouse Electric Corp., Baltimore, Md.
Branson, N. G., des. engr., General Electric Co., Schenectady, N. Y.
Chaney, Y. T., ind. engg. dept., Trumbull Elec. Mfg. Co., Norwood, Ohio.
Crawford, C. H., sect. leader, General Electric Co., Schenectady, N. Y.
Curtis, T. E., chief engr., Southern States Equipment Corp., Birmingham, Ala.
Davis, W. G., chairman, elec. engg. dept., Fenn College, Cleveland, Ohio.
Delfs, J. M., ind. engg. div., General Electric Co., Schenectady, N. Y.
Dole, A. R., assoc. tel. engr., Signal Corps, U. S. Army, Presidio of San Francisco, Calif.

Falls, O. B., Jr., elec. engr., General Electric Co., Schenectady, N. Y.
Fox, G. W., electronics ship supt., U. S. Navy Yard, Charleston, S. C.
Gardner, V. E., elec. engr., Bureau of Ships, U. S. Navy, Washington, D. C.
Gateka, F. F., elec. supt., Public Service Co. of Oklahoma, Lawton, Okla.
Geiger, W. H., div. supt., Public Service Elec. & Gas Co., Hackensack, N. J.
Hansen, E., asst. supt., production, Florida Power Corp., St. Petersburg, Fla.
Hoenie, N. J., asst. chief engr., Lincoln Electric Co., Cleveland, Ohio.
Horrell, R. F., des. engr., Westinghouse Electric Corp., E. Pittsburgh, Pa.
Hyde, G. C., pres., Gulf Public Service Co., Inc., & Louisiana Pub. Utilities Co., Inc., Dallas, Tex.
Johnson, L. L., project engr., General Motors Corp., LaGrange, Ill.
Krishnaswami, A. C. K., director, Seshasayee Bros., Ltd., Trichinopoly, S. India.
Kundel, T., Major, U. S. Army, Jefferson Proving Ground, Madison, Ind.
Lambert, J. S., Major, War Dept., Washington, D. C.
Leppert, J. H., tech. supervisor, Tennessee Eastman Corp., Oak Ridge, Tenn.
Lindemann, W. E., elec. engr., Tennessee Valley Authority, Wilson Dam, Ala.
Linden, C. A., engr., General Electric Co., Schenectady, N. Y.
Long, V. O., instructor, elec. engg., U. S. Naval Academy, Annapolis, Md.
Marrs, R. E., application engr., General Electric Co., Schenectady, N. Y.
Mason, C. R., section leader, General Electric Co., Schenectady, N. Y.
McConnell, G. B., elec. supervisor, Boeing Aircraft Co., Seattle, Wash.
McMaster, R. C., research engr., Batelle Memorial Institute, Columbus, Ohio.
Meahl, H. R., elec. engr., General Electric Co., Schenectady, N. Y.
Merrill, J. R., sr. engr., Raytheon Mfg. Co., Waltham, Mass.
Miller, E. F., long lines dept., American Tel. & Tel. Co., New York, N, Y.
Miller, W. E., elec. engr., General Electric Co., Schenectady, N. Y.
Minocha, K. R., elec. adviser & inspector, Government of Cent. Provinces & Berar, Nagpur, India.
Moler, M. A., head, pr. equip. branch., U. S. Maritime Commission, Oakland, Calif.
Moore, L. M., engr., Central New York Power Corp., Syracuse, N. Y.
Moore, R. D., design engg., General Electric Co., Schenectady, N. Y.
Morgan, J. F., plant engr., Mercury Mills, Ltd., Hamilton, Ont., Can.
Morley, D. M., engr., General Electric Co., Schenectady, N. Y.
Mouat, T. W., Jr., asst. research engr., National Research Council, Ottawa, Can.
Peirce, R. M., research elec. engr., American Steel & Wire Co., Electrical Cable Works, Worcester, Mass.
Porter, F. M., elec. engr., American Gas & Electric Service Corp., New York, N. Y.
Quarles, L. R., assoc. prof., University of Virginia, Charlottesville, Va.
Ridgley, C. J., elec. engr., I-T-E Circuit Breaker Co., Philadelphia, Pa.
Roberts, F. C., engr., General Electric Co., Schenectady, N. Y.
Rodhouse, T. E., line des. engr., General Electric Co., Pittsfield, Mass.
Schwan, C. F., generator des. engr., Ohio Crankshaft Co., Cleveland, Ohio.
Sproul, P. T., member of technical staff, Bell Telephone Labs., Inc., New York, N. Y.
Story, T. H., adv. dev. engr., RCA Victor Div., Radio Corp. of America, Camden, N. J.
Walker, R. E., asst. chief des. engr., Smith & Gillespie, Jacksonville, Fla.
Wanamaker, R. L., elec. engr., General Electric Co., Schenectady, N. Y.
Weil, W. S., Jr., engr., General Electric Co., Philadelphia, Pa.
Whitehead, E. G., Lieut., U. S. Coast Guard Headquarters, Washington, D. C.
Williams, E. W., meter foreman, Montana Power Co., Butte, Mont.
Witzke, R. L., cent. station engr., Westinghouse Electric Corp., East Pittsburgh, Pa.
Yost, C. H., elec. engr., Curtis Publishing Co., Philadelphia, Pa.

59 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before November 15, 1945 or January 15, 1946, if the applicant resides outside of the United States or Canada.

To Grade of Member

Beachley, R. W., Stone & Webster Engr. Corp., Knoxville, Tenn.
Brough, R., Telephone Manager's Office, Glasgow, Scotland
Brown, A. M., Commonwealth Edison Co., Chicago Ill.
Brown, H. R., Corps of Engineers, Omaha, Nebr.
Claes, A. J., Socony-Vacuum Oil Co., East St. Louis, Ill.
Dave, N. M., New Standard Engg. Co., Ltd., Bombay, India
Derr, J. D., No. Carolina Shipbuilding Co., Wilmington, N. C.
Dibrell, J. W., Naval Ordnance Lab., Washington, D. C.
Egger, C. J., Buckeye Laboratories Corp., Cleveland, Ohio
Fink, D. G., Electronics Magazine, New York, N. Y.
Fisher, J. T., Bell Tel. Co. of Canada, Toronto, Ont., Canada
Gelow, M. L., Graham Paige Motors, Detroit, Mich.
Haller, G. L., Col., Air Corps., Air Technical Serv. Cmd., Dayton, Ohio
Kellerman, W. C. (Re-election), Commonwealth Edison Co., Chicago, Ill.
Leas, J. W., Maj., Sig. C., AUS, Naval Research Lab., Washington, D. C.
Leiper, F. M., Berker & Wheeler, New York, N. Y.
Manfredo, I. H. (Re-election), Navy Yard, Bayonne, N. J.
Martin, H. W. (Re-election), Stevenson, Jordan & Harrison, Ltd., London, England
Mason, J. A., American Tel. & Tel. Co., Philadelphia, Pa.
May, G. C., U. S. Navy Dept., Minneapolis, Minn.
Meade, G. R., Reconstruction Finance Corp., Washington, D. C.
Parkinson, J. A., A. T. & S. F. Ry., Chicago, Ill.
Parnell, J. G., Board of Public Works, Niles, Mich.
Ray, J. H., Lt. Col., Engr. Construction Command, San Francisco, Calif.
Robertson, D. S., Dominion Government, Ottawa, Ont., Canada
Sands, L. G., Curtiss-Wright Corp., Bloomfield, N. J.
Ware, M., Sig. Corps, War Dept., Arlington, Va.
Wilder, H. F., Western Union Telegraph Co., New York, N. Y.
Zimmermann, F. O., Federal Tel. & Radio Corp., Chicago, Ill.

29 to grade of Member

To Grade of Associate

United States and Canada

1. North Eastern

Burnham, J. M., Eastman Kodak Co., Rochester, N. Y.
Cohen, A. M., Ward Leonard Elec. Co., Mount Vernon, N. Y.
Cunniff, T. W., Hazeltine Electronics Corp., Little Neck, L. I., N. Y.
Ewaskio, H., Jr., Great American Industries, Meriden, Conn.
Frohock, W. S., Sylvania Elec. Products, Inc., Danvers, Mass.
Lincoln, R. T., Binghamton Board of Education, Binghamton, N. Y.
Rossi, R. P., Gen. Elec. Co., Schenectady, N. Y.

2. Middle Eastern

Adair, J. M. (Re-election), Westinghouse Elec. Corp., Newark, N. J.
Ayllon, H. R., Gen. Elec. Co., Philadelphia, Pa.
Brown, A. (Re-election), Phila. & Reading Coal & Iron Co., Pottsville, Pa.
Chamberlain, E., British Air Comm., Washington, D. C.
Corcoran, J. P., Westinghouse Elec. Corp., Washington, D. C.
Danaher, J. J., Jr., Capt. U. S. Army, Nat'l Bureau o Standards, Washington, D. C.
Dreisbach, R. J., The Ohio Public Service Co., Port Clinton, Ohio
Geiger, P. M., Sperry Gyroscope Co., Inc., Baltimore, Md.
Giloy, E. W., The Glenn L. Martin Co., Baltimore, Md.
Gitschier, J. F., Pennsylvania Transformer Co., Pittsburgh, Pa.
Graham, M. A., Thomas & Betts Co., Elizabeth, N. J.
Hurford, A. C., Jr., Phila. Navy Yard, Phila., Pa.
Krantz, A. W., Reliance Elec. & Engg. Co., Cleveland, Ohio
Leavesley, C. D., Phila. Elec. Co., Phila., Pa.
Lichstein, M., Philadelphia Navy Yard, Philadelphia, Pa.
MacKinnon, J. D., Jr., Lt., USN, Bureau of Naval Personnel, Washington, D. C.
Moore, W. N., Jr., Simplex Radio Corp., Sandusky, Ohio
Owens, J. B., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Pease, J. O., Rumsey Elec. Co., Washington, D. C.
Po-Wen, H., % Public Service Elec. & Gas Co., Newark, N. J.
Salko, J. R., Pa. Transformer Co., Pittsburgh, Pa.
Schwartz, L. S., Capt., Air Corps., Naval Research Lab., Washington, D. C.
Stone, J. C., Sperry Gyroscope Co., Inc., Phila., Pa.
Tyndall, J. T., Delaware Power & Light Co., Wilmington, Del.
Vidmar, J. F., The Ohio Bell Tel. Co., Cleveland, Ohio
Watson, H. A., Jr., Marine Equipment Co., Lakewood, Ohio
Wicher, W. E., Navy Ordnance Lab., Washington, D. C.
Wilson, S. A., Muse Art Engineering Corp., Philadelphia, Pa.

3. New York City

Bull, C. B. (Re-election), 129 East 69th St., New York, N. Y.
Dillon, S. V., Johns-Manville Sales Corp., New York, N. Y.
Ellis, H. J., Lt. (jg), USNR, — F.P.O., New York, N. Y.
Frankiewicz, S. A., N. Y. Navy Yard, Brooklyn, N. Y.
Santogrossi, D. J., Bendix Avia. Corp., Brooklyn, N. Y.
Stanton, R. L. (Re-election), Fed. Pr. Comm., New York, N. Y.

4. Southern

Anderson, O. E. E., Lt., USNR, Miami, Florida
Cutchins, A. P., Mutual Boiler Ins. Co., New Orleans La.
Johnson, M. D., Cabell Elec. Co., Jackson, Miss.
Lowe, H., Aluminum Co. of America, Atlanta, Ga.
Miller, N. J., Tennessee Valley Authority, Chattanooga, Tenn.
Rothwell, H. E., Va. Elec. & Pr. Co., Richmond, Va.
Sledge, L. N., Charleston Navy Yard, Charleston, S. C.
Ulm, R. W., Tenn. Eastman Corp., Oak Ridge, Tenn.
Warner, C. W. (Re-election), Ga. Power & Lt. Co., Valdosta, Ga.

5. Great Lakes

Boesenberg, J. J., Illinois Bell Telephone Co., Chicago, Ill.
Brown, H. L., Public Serv. Co. of No. Ill., Joliet, Ill.
Carman, W. J., Illinois Bell Telephone Co., Chicago, Ill.
Dibble, H. H. (Re-election), Indiana & Michigan Elec. Co., South Bend, Ind.
Duff, G. H., Westinghouse Elec. Corp., Peoria, Ill.
Dugan, K. L., General Motors Corp., Anderson, Ind.
Ewald, L. J., Ill. Bell Tel. Co., Chicago, Ill.
Farmer, J. D., Indiana & Michigan Elec. Co., South Bend, Ind.
Fuller, F. C., Jr., Illinois Bell Tel. Co., Chicago, Ill.
Garling, K. E., Fed. Elec. Co., Chicago, Ill.
Hansen, L. E., D. W. Onan & Sons, Minneapolis, Minn.
Hartman, C. J., The Commonwealth & Southern Corp., Jackson, Mich.
Hasselbacher, H. H., Chicago Burlington & Quincy RR Co., Chicago, Ill.
Massaro, A. V., Allis-Chalmers Mfg. Co., Springfield, Ill.
Miller, W. L., American Tel. & Tel. Co., Chicago, Ill.
Nibbelin, C. J., Commercial Solvents Corp., Peoria, Ill.
Parker, H. E., Electrical Testing Co., Peoria, Ill.
Sawicki, W. L., Winpower Mfg. Co., Newton, Iowa
Schwartz, P. N., Commonwealth Edison Co., Chicago, Ill.
Sedgwick, W. C., Central Illinois Light Co., Peoria, Ill.
Sievers, G. A., Line Material Co., South Milwaukee, Wis.
Stokes, H. L., Illinois Bell Tel. Co., Chicago, Ill.
Ullery, R. M., Indiana & Michigan Elec. Co., South Bend, Ind.

7. South West

Bell, R. A., Dallas Power & Light Co., Dallas, Tex.
Frohardt, A. E., Wagner Elec. Corp., St. Louis, Mo.
Gehlsen, R. G., Mines Equipment Co., St. Louis, Mo.
McNeely, J. S., Southwestern Bell Tel. Co., Dallas, Tex.
Sneed, J. W., Jr., Consolidated Steel Corp., Orange, Tex.
Steely, T. A., Fraser-Brace Eng. Co., Inc., Camden, Ark.
White, F. A., 1411 8th St., Lubbock, Tex.

8. Pacific

Bastow, W. R., Lt., USNR, San Francisco, Calif.
Bullis, W. R., Salinas Junior College, Salinas, Calif.
Burnell, H. L., Allis-Chalmers Mfg. Co., San Francisco, Calif.
Chapel, C. E., Northrop Aircraft, Inc., Hawthorne, Calif.
Dexter, G. W., University of California, Berkeley, Calif.
Fowler, L. S., Lt., USNR, Yard Public Works, San Francisco, Calif.
Hales, W. L., Solar Aircraft Co., San Diego, Calif.
Hodgson, R. W., Douglas Aircraft Co., Los Angeles, Calif.
Lehan, F. W., Calif. Inst. of Tech., Pasadena, Calif.
Murphy, D. M., U.S.E.D., San Francisco, Calif.

9. North West

Shaw, W. L. (Re-election), Utah Pr. & Lt. Co., Salt Lake City, Utah

10. Canada

Lewis, T. H., Hydro-Elec. Pr. Comm. of Ont., Burlington, Ont., Can.
Scroggs, S. H., Jr., Small Elec. Motors, Toronto, Can.
Shaw, D. T., Capt. Canadian Army, Montreal, Can.
Yeoman, A. R. A., Elec. Lt. Cmdr., RCNVR, Halifax, N. S., Can.

Elsewhere

Aziz Iskander, A., Atf Power Station, Mahmoudieh, Egypt
Craske, C. H., Imperial Chemical Industries, Ltd., Cheshire, England
Dalal, M. K., S. N. Paruck Parsi Polytechnic, Surat, India
Green, O. R., Electricity & Water Wks., New Amsterdam, B. G.
Pillai, K. N. R., Maj., Indian Posts & Telegraph Dept., Dacca, India
Rawal, C. A., Dept. of Industries, Govt. of Bombay, Daria Mahal, Surat, India
Sapiro, N. A., Asso. Elec. Engr., U.S.E.D., Ft. Armstrong, Honolulu
Tang, T. Y., Metropolitan-Vickers Elec. Co., Manchester, England

Total to grade of Associate

United States and Canada, 95

Elsewhere, 8

OF CURRENT INTEREST

5,000 New Products and Procedures From Atomic-Bomb Research

Immediate benefits to American industry in new inventions and new and improved products and procedures of manufacture resulting from the atomic-bomb project were foreseen recently at a luncheon meeting of business-paper editors held in New York, N. Y., under the auspices of The M. W. Kellogg Company, chemical engineers of Jersey City, N. J., and New York. The Kellogg Company arranged the meeting on behalf of its wartime subsidiary, The Kellex Corporation, a noncommercial industry-wide unit which engineered the designing, construction, and operation of the diffusion-process plant of the atomic-bomb project at Oak Ridge, Tenn. As a result of the inventive, scientific, industrial, and engineering advances incident to work on the atomic-bomb project, the Kellex Corporation estimates that more than 5,000 new and improved products and procedures are now available to American industry, awaiting only Government release for volume production.

The Kellex Corporation, which included in its personnel a cross section of the nation's scientific and engineering talent loaned for the war emergency by many companies, was formed for the purpose of developing procedure and designing equipment for volume production of uranium 235, the essential ingredient in the atomic-bomb project. The success of this undertaking and the technical soundness of the diffusion plant's processes and equipment are recognized in the announcement that, of the three methods in use at Oak Ridge it is the only plant which will be continued on normal operation. This decision, it is stated, was the result of a new postwar policy in which emphasis is shifted from all-out war production at any cost to concentration on a single process which would yield maximum peacetime production consistent with efficiency and economy of operation. Wartime performance of the diffusion plant was such that Government authorities selected this process alone for the separation of U-235 for postwar use.

The development work for this method had to be transformed from a highly theoretical concept without even a laboratory process upon which to base design and performance data into an efficient multistage commercial gas-recycling process. So vast was the undertaking and so enormous the cost that normally no single corporation or group of corporations would even consider industrial research on this subject with such little prospect of success.

The total cost alone of separating the U-235 isotope by the diffusion process in useful volume accounted for a substantial portion of the over-all figure of $2,000,000,000. The vast sum of money spent can be considered, according to the corporation, not only as a wartime necessity or as a preliminary to developing superpower resources in the future, but also as the Government's contribution toward the betterment of industry as a whole.

For industry does not have to wait for atomic power to utilize the experience of the project. Many lessons have been learned which can and will be applied immediately to more efficient processing. All these lessons cannot be revealed, at present, but they are in the minds of engineers and firms participating in the project and will be inextricably bound up with their future thinking, engineering design, construction, and processing. Some items in these fields can be mentioned and will afford some idea of the enormity of the problem and the scope of its application toward the betterment of industry.

The following partial list of industries gives some indication of how they will benefit from knowledge gained in the U-235 problem:

1. Petroleum refining.
(*a*). Improved pumping.
(*b*). New-type more efficient heat exchangers.
(*c*). Mass spectroscope (continuous analytical control).
(*d*). Possible new methods of separating gasoline fractions.
(*e*). Improved automatic control.

2. General chemical and processing industries.
Same improvements as in petroleum refining.

3. Manufacture of pressure and vacuum vessels.
(*a*). Checking welds.
(*b*). Pretesting vessels for leaks before operation.
(*c*). Improved vacuum techniques.

4. High-vacuum industries.
(*a*). Improved vacuum methods for vitamin distillation.
(*b*). New methods of detecting high vacua in electronic-tube manufacture.
(*c*). Low-pressure low-temperature dehydration of foodstuffs.

5. Gas-processing industries.
(*a*). Diffusional separation of helium from natural gas.
(*b*). Efficient separation of hydrogen from process gases.
(*c*). Diffusional separation of oxygen and rare gases from air.
(*d*). New techniques in gas recycling.

6. Electrical industry.
(*a*). New electronic techniques in high vacua.
(*b*). Improved microsensitive instrumentation.

7. Medical profession.
(*a*). A low-cost more abundant source of radioactivity.
(*b*). Improved protective methods for combatting toxicity in industry.
(*c*). Extension of cancer therapy.

8. Refrigeration industry.
(*a*). Increased safety in equipment.
(*b*). Improved handling of fluorides for refrigerants.

9. Industries employing corrosive chemicals.
(*a*). New pump and valve lubricants and packing methods.
(*b*). New treatment of metal surfaces to prevent corrosion.
(*c*). Improved safety practices.
(*d*). Completely enclosed pumps operated from exterior by induction.

CORROSION FACTORS

From the start the project encountered staggering obstacles. Uranium, being a solid, had first to be transformed into a gas for utility in the selected gas-diffusion process. This meant selecting a compound of uranium with some other element which would be gaseous at nominal temperatures and from which elemental uranium could be regained readily after diffusion. After much experimentation, which included uranium hexafluoride, UF_6, and other gases, suitable process gases were selected. One of the major advantages of UF_6 which brought it into special consideration was that fluorine, having only one isotope, would not complicate the separation by adding new combinations which would diffuse at varying speeds. Uranium hexafluoride is a solid at room temperature but fortunately turns into a gas at 56 degrees centigrade. Unfortunately, however, like most fluorine compounds, it was highly reactive, physiologically poisonous, and introduced problems of corrosion which pointed toward difficulties in production and handling. In the words of one Kellex spokesman "uranium hexafluoride is one of the hardest things to handle in the history of mankind."

It was found that practically all the techniques and developments gained in the successful study of the problem could be carried over into a number of industries plagued by corrosion factors through improvement in equipment and processing. The results indicated a saving of millions of dollars annually in the conservation of critical equipment and materials, minimum breakdown of moving parts, and increased safety for workers.

In the process it was imperative that no material in contact with the process gas react with it, as such corrosion would lead not only to plugging of the microscopic pores of the diffusion barrier and various mechanical failures but also to absorption (that is, virtual disappearance) of enriched U-235 isotope. Obviously, therefore, standard-type valves and piping could not be used; instead, new methods of pretreating metal surfaces against corrosion were worked out, new coolants, piping, new-type heat exchangers, lubricants, pumps, and packing were developed to satisfy the stringent requirements.

APPLICATION OF NEW CORROSION KNOWLEDGE TO INDUSTRY

Hydrogen fluoride is an important isomerization and alkylation catalyst in petroleum refining, as well as an important raw material in the production of aluminum and refrigerants. It is, however, so highly active and dangerous that industry has not yet capitalized on many of its potentialities. Its handling now may be made safer and simpler without excessive maintenance costs, and as a result its increased use in industry may be realized.

Other important starting materials for a host of industrial products, such as sulfur dioxide, hydrogen chloride, and the mineral acids (sulfuric, nitric, and phosphoric), all have presented severe problems of transfer and corrosion with particular emphasis on valve lubricants and pump packings. These difficulties can be simplified greatly by application of the knowledge gained through the extensive experimentation with UF_6 and the other related gases.

PUMPS

The story on pumps, the heart of the process and one of its most difficult problems, is particularly interesting and applicable to modern industry. Thousands of pumps operating under reduced pressure at Oak Ridge created problems in vacuum technique on an unheard of scale. Other thousands operated at nominal pressures. But regardless of the type or service none could leak or corrode, and all had to have as small a volume as possible. Many different types of centrifugal blower pumps and sylphon-sealed reciprocating pumps were tried out and new types developed. For example, in one of the pumps for the larger stages the impeller was driven through a coupling containing a very novel and ingenious new seal. Another type of pump was completely enclosed, its centrifugal impeller and rotor being run from the outside by induction.

Top-flight pump designers from leading manufacturers in this country collaborated in research at the central Kellex laboratories in Jersey City and succeeded to a remarkable degree in increasing industry's knowledge of this all-important phase of processing. For security reasons the practical applications of the new types of pumps developed cannot yet be disclosed publicly. However, the engineers who participated in this phase of the project have brought to their parent companies a vastly increased lore of new techniques which cannot help but be reflected in increased service to their customers.

Perhaps the most significant advance in pump design which has been accomplished most successfully is the utilization of supersonic velocities of a very high order (Mach numbers of over 1.0).

BARRIER REQUIREMENTS

Literally acres of porous barriers were required for the gas diffusion plant with billions of holes smaller than 0.01 micron. Despite the high degree of porosity required, such barriers had to be able to withstand a pressure head of one atmosphere. The pores had to be of uniform size and spacing and could not become enlarged or plugged up as the result of direct corrosion or dust coming from corrosion elsewhere in the system, and the barriers had to be adaptable to manufacture in large quantities and with uniform quality.

One of the chief reasons for the lack of diffusion techniques in industry today has been the barrier problem. Few, if any, corporations cared to expend the prohibitive time and money in the necessary research on this problem, until it was made necessary by the exigency of the situation. Almost at the last minute an excellent barrier was developed, and today these operate successfully throughout the more than several thousand stages.

APPLICATION OF DIFFUSION PRINCIPLES TO INDUSTRY

Now that a large part of the basic research on diffusion barriers and their application to full-scale industrial separations has been completed, particularly with reference to gas recycling and instrumentation, the next development would seem to be the separation of helium from natural gas by diffusion techniques rather than by the present refrigeration method. Helium is so light in comparison to other components of natural gas that its diffusion velocity through a porous barrier is over twice as great as the next lightest compound present in the same source.

It may be still easier to isolate hydrogen by these new methods from a number of process gases now used merely as fuel, because the diffusion velocity of hydrogen, the lightest of our elements, is over four times that of any compound associated with it.

The isolation of ethylene by incorporating diffusion barriers as an integral part of cracking units conceivably could supply an abundant source of this versatile chemical used for the manufacture of synthetic rubber, plastics, antifreeze, alcohol, and many other products.

The preparation of oxygen and rare gases from air without resorting to refrigeration and fractional distillation is another possible application, when economic methods are developed.

The direct isolation of natural gasoline fractions from crude petroleum without resorting to distillation, and new types of fractionating columns for the petroleum-refining industry also appear feasible.

INSTRUMENTATION

If pumping is the heart of processing, then instrumentation is the brain. No continuous process could function efficiently without adequate automatic control. In the gaseous diffusion plant the problems of instrumentation were far greater than in any other industry, because the theory involved the assumption that diffusion took place through an infinite number of stages, whereas practicability dictated that such stages be limited in number.

Even so, several thousand stages were required, necessitating an intricate system of gas recycling involving abnormally large volumes of gases in relation to the finished product and continuous high-precision analytical control. About half of the gas processed in each stage diffused through the porous barrier as enriched U-235 product and after repressuring was sent on to the next higher stage for further concentration; the impoverished half also was repressured and recycled through the next lower stage. The recycling involved was enormous, over 100,000 times the volume of the final enriched gas.

There were developed to meet these needs the most precise continuous automatic analytical control instruments ever produced by man, it is claimed. This refinement is one of the outstanding features of the gas-diffusion plant and constitutes one of its most important applications to industry today. Instruments which before had existed only in research laboratories were improved upon and adapted to commercial use; completely new prototypes were conceived, developed, and put into mass production. The result is that now there is available to industry a more nearly perfect system of continuous automatic control than ever has existed.

APPLICATIONS OF NEW INSTRUMENTATION TO INDUSTRY

Mass Spectroscope. One of the developments employed is a new type of mass spectroscope, which every petroleum refiner will welcome for control of cracking operations and transfer line analysis. The mass spectroscope has been employed for several years in research laboratories and even within the last two years in certain phases of the refining industry but never on the perfected scale developed at Oak Ridge. The foremost instrument engineers and physicists in the United States and England devoted their full time not only toward gearing this instrument to continuous control but also to expanding United States capacity for its quantity output. In no other country has electronic research been applied on so grand a scale. The mass spectroscope is an electronic device for analyzing gases both qualitatively and quantitively from a mass standpoint by separating a beam of dissimilar gas molecules into separate beams according to their formula weight. Determinations are very fast, require only a thimbleful of gas, and make obsolete the formerly used Orsat and chemical analyses, particularly for the purposes of continuous control where instantaneous changes must be effected the moment a process swings off the line.

Its potential uses in industry include the accurate analysis of natural gas or any process gas; the continuous automatic control of any gaseous process such as alkylation, dehydrogenation, vapor phase cracking, and so forth; the checking of inert gases such as nitrogen used to provide a protective atmosphere in furnaces and so forth; the checking of the completeness of any evacuation process, as in the manufacture of radio tubes; the detection of impurities; and many others. Industry will not have to wait for benefits from this versatile tool, because production facilities have been increased enormously since the new type was created.

Leak Detector. A second development, aptly and simply called the leak detector, is more sensitive than any other existing device previously utilized for the same purpose. It played an important part in ensuring that all parts of the gaseous-diffusion plant were vacuum tight. Any leaks out of or into the system would be damaging both from the standpoint of loss and of contamination of an exceedingly valuable material. The leak detector is well adapted for locating annoying leaks in industrial high-vacuum processing industries, such as vitamin manufacture, in which even microscopic leaks undetectable by the familiar ammonia–hydrogen-chloride method or Tesla coil method are still potent enough to prevent drawing the necessary high vacuum on the equipment. Other potential uses include the pretesting of pressure and vacuum apparatus before putting it in service, checking equipment in operation to ensure no wasteful loss or contamination, the testing of welds for minute pores which otherwise would escape detection, and ensuring the physiological safety of refrigeration equipment employing toxic coolants.

Heat Exchangers. Of great interest to the petroleum-refining industry is the development of a new-type heat exchanger. Since an unavoidable concomitant to pumping gas is heating it and since enormous volumes of gas were processed, individual cooling units for each stage had to be developed. A brand new type of heat exchanger was conceived for this purpose and developed up to the production stage. A manufacturer then was selected and shown how to make it, even to the extent of redesigning his equipment so that thousands of units could be turned out quickly. The units were installed and functioned very well.

POSSIBLE MEDICAL AND PHYSIOLOGICAL BENEFITS

Because of the variety and multiplicity of radioactive products which can be produced by means of U-235, humanity faces the prospect of soon having available for therapeutic medicine radioactive materials possessing a wide variety of properties. It is logical to expect, therefore, that these new materials will be suitable for products offering a greater range of usefulness, and at a lower cost than radium.

The possibility exists of incorporating a micro quantity of a radioactive isotope in food to observe its metabolism in the body of experimental animals. Such tagged material could be traced readily in its passage through the organs of the body.

MONEY NOT WASTED

Kellex representatives urged that it be borne in mind that the afore-mentioned benefits accruing to American industries as a result of knowledge gained in the development of the gas-diffusion plant represent only a small part of that permitted to be revealed at this time. The total cost of the project, $2,000,000,000, actually only represented eight days of war cost to the United States.

If it be estimated that the war would have lasted another six months the actual saving could be estimated at $45,000,000,000.

Latest Army Radar Set Guards Coasts and Guides Ships

Existence of seacoast fire-control radar, a new set, which it is claimed "will revolutionize our coastal defenses" and will guide incoming ships, even those without radar equipment, to port through fog and darkness, recently was revealed by the Army.

The apparatus was designed by the radiation laboratories at Massachusetts Institute of Technology, Cambridge, for the Army Signal Corps, and sets had been in operation along United States coastlines and on the coast of Iwo Jima before the war ended.

Detection of vessels at least 25 miles at sea with a definition hitherto impossible for shore-to-sea sets has been accomplished with the new apparatus. Its accuracy of definition is within five yards in any direction at the effective firing range of 12 miles. Used for nonmilitary purposes, it will allow the safe guiding to anchorage of ships which either lack radar entirely or have equipment that is out of commission. The shore radar operator, possessing what amounts to a motion-picture view of the approaching ship in his radar oscilloscope, can warn the ship by radiotelephone of all obstacles in its path.

As a defense weapon the new set enables accurate nighttime firing, because the radar automatically relays information on range and bearing of the target to the guns. Such a degree of definition has been secured in sighting objects that a fleet of several hundred large and small ships, detected at a distance of 30 miles, shows up as separate dots of light, and an area of one mile square can be brought to such magnification that a ship five miles away can be seen to turn, and sometimes can be identified as to class.

A unique feature of the new set is the extremely narrow beam of radio pulses which it emits—one half of a degree wide. At a range of 5,000 yards the beam is only 50 yards wide. Surveillance radar sets formerly used to scan the sea from land employed beams that were 60 to 80 times as wide.

EDUCATION....

Educational Advantages for Veterans

Rensselaer Polytechnic Institute, Troy, N. Y., recently announced a co-operative plan with industry to aid in replenishing the nation's supply of scientific and technological personnel.

According to Livingston W. Houston, president of the institute, the General Electric Company has agreed to participate in training as many as 80 men at a time as its share in the program and other nationally known companies also are arranging to take part.

The plan is said to differ from the average college-industry plan in that it will carry students through at least to the master's degree and enroll only those who indicate talent and ability for graduate study and research. Rensselaer Polytechnic Institute and the co-operating industry will select the candidates jointly from the regular student body in their sophomore year.

The program will get under way November 1. While studying various branches of engineering, physics, and chemistry, students will spend about 30 per cent of their time in shops or laboratories of the industries, for which they will receive wages. Neither the student nor the company is obligated, one to the other, as to later employment.

The plan will enable veterans to receive a high standard of education in cases where, because of dependents, the educational benefits of the "GI Bill" would not otherwise be sufficient.

The institute will also open on November 1, 1945, a program of co-ordinated evening courses leading to baccalaureate and graduate degrees as well as individual courses in independent subjects. The work covers engineering, science, management, English, literature, history, and economics. This plan will likewise offer an opportunity to veterans who find the financial allowances under the bill insufficient to permit them to go to college without working at the same time.

MIT to House Returning "GI's." The Massachusetts Institute of Technology, Cambridge, will build 100 houses for married veterans who are planning to resume their education this autumn or in the spring of 1946. The decision to build came after a survey of housing conditions and facilities of Greater Boston showed that it would be practically impossible for a veteran returning to the college to find suitable living quarters. The departments of civil and mechanical engineering provided advice on grading, roads, paths, drainage, and electric layouts for the houses which will be erected on land belonging to the institute and adjacent to it.

Polytechnic Institute of Brooklyn Aids Veterans

A series of eight degree-guidance circulars has been prepared by the Polytechnic Institute of Brooklyn, N. Y., as a means of giving specific information to the many inquirers from all parts of the world. Each of the circulars is devoted to a full outline of the four-year requirements leading to the bachelor degree in electrical engineering; aeronautical engineering; chemistry; chemical engineering; civil engineering; mechanical engineering; metallurgical engineering, and physical science.

To assist returning veterans, Polytechnic Institute in the spring of 1945 set up a counseling service for the use of men already separated from service and for men who were still in service and who wanted to know what requirements they must meet. During the past academic year the institute had an enrollment of 136 veterans. In the autumn of 1943 veterans at the institute organized the first chapter of Gamma Iota Alpha, the "GI" association now expanding as a collegiate veterans' association in college chapters throughout the United States.

Two curricula are now available at the institute in electrical engineering, one featuring power and industrial applications and the other communications and electronics. They include new courses in electrical controls, power systems, electromagnetic fields, and electroacoustics.

Fellowships Granted by Eastman Kodak

To assist universities in reducing the postwar dearth of young men with advanced technical training, the Eastman Kodak Company, Rochester, N. Y., will expand its granting of annual fellowships into a program of aid to graduate students of chemistry, physics, mechanical and electrical engineering, and business administration. This enlarged program is to provide 12 fellowships for doctoral work and ten fellowships for masters' work. The previous Eastman Kodak grants, numbering only six, were confined to the field of chemistry and chemical engineering.

Of the awards to be granted persons pursuing doctoral training, one fellowship is designated for chemical engineering at the Massachusetts Institute of Technology, Cambridge, Mass., another is for work in organic chemistry at the University of Illinois, Urbana, and another is for the study of physical chemistry at the University of Rochester, Rochester, N. Y. The nine other fellowships for doctoral work—six in chemistry and three in physics—are to be rotated among various universities from year to year.

To encourage graduate training in the field of mechanical engineering, the Eastman

Kodak Company is offering four fellowships to men majoring in design in work toward their master's degree. It is planned that two fellowships will be awarded, in addition, to students completing their master's degree in electrical engineering. The company's interest in this field has evolved largely from its increasing concern with the application of the principles of electronics and electrical engineering. These six fellowships are to be utilized at different universities each year.

A major purpose of the increased fellowship grants is to augment the research activity of the universities, thus raising the quality of instruction and enhancing the training of students becoming available for industrial positions.

Special Courses for Veterans at Stevens and Columbia

A pre-engineering training course for veterans desiring to study engineering who have not completed the required preparatory studies or who wish to review high-school subjects before starting college work in engineering has been organized by Stevens Institute of Technology, Hoboken, N. J. Regular faculty members will supervise the instruction in physics, chemistry, mathematics, and English which will comprise the course.

For veterans who intend to operate small businesses and have insufficient time for a full college program, Columbia University has designed an eight-week intensive course to be given by the school of business and university extension. Students will receive instruction in the fundamentals of accounting, finance, marketing, organization, buying and inventory control, advertising, labor relations, booms and depressions, risk and insurance, taxation, planning and budgeting, and business policy, as well as special instruction in the operations and problems of particular types of small business. Classes will be supplemented by panel discussions led by men experienced in operating small business or men who are specialists in serving small business.

Technical Subjects Urged for Schools. The vocational high school division of the schools of New York, N. Y., has prepared a report urging the introduction of technical courses in ten of the city's trade schools. If approved this plan would offer technical training at the secondary-school level to a larger percentage of students, and would prepare students for posts as vocational technicians or for admission to engineering colleges. The report noted that during the period of rapidly changing economic and technological conditions, an attempt, already started, should be continued to train boys and girls to meet these conditions.

Television at Syracuse. Syracuse University, Syracuse, N. Y. has reserved an "Intra-Tel" system—wired television—from the General Electric Company, Schenectady, N. Y., for postwar delivery. William Pierson Tolley, chancellor of the university, said that the television equipment will be used to conduct various classroom teaching experiments, as well as teaching television programming and other techniques to students. He said that Syracuse University students would be given the opportunity of studying various television operations such as script writing, costume and stage-set designing, lighting, camera operation, stage and technical direction, picture and sound control and other transmitter operations, and that the university's experience would be made available to other educators.

Educators Inspect Navy Postgraduate School

A group of recognized engineering educators recently was invited by the chief of naval personnel to visit the United States Naval Postgraduate School at Annapolis, Md., for the purpose of inquiring into the character and scope of instruction, and to offer suggestions for the arrangement of the Navy's postwar plans for graduate education of its officers. The group which included W. B. Kouwenhoven (F '34) dean, school of engineering, Johns Hopkins University, Baltimore, Md., also considered the propriety of authorizing the master-of-science and doctor-of-science degrees to student officers who fulfilled established requirements.

The postgraduate school was established at the academy in 1909 with the purpose of offering advanced technical education to meet specific naval needs. In the interests of furthering its educational program, the Navy Department has granted authority to the postgraduate school to participate in a program for an exchange of professors with selected colleges and universities.

Survey of Latin America Engineering Education

Dean S. S. Steinberg of the college of engineering, University of Maryland, College Park, will return to the University late this month from a good-will tour of Latin America made in the interest of engineering education. He traveled as the guest of the State Department in behalf of its division of cultural co-operation.

The purpose of his trip was to make a survey of engineering education in the American republics; promote closer relations between the engineering educators of Latin America and the United States; arrange for exchange of professors, and provide for a wider interchange of engineering and technical publications.

For this trip Dean Steinberg was designated official representative of the Society for the Promotion of Engineering Education.

Electrical Engineering for Service Men. A survey recently undertaken by Professor B. A. Thresher, director of admissions, Massachusetts Institute of Technology, Cambridge, revealed that a majority of the service men interested in an engineering education picked electrical engineering as their foremost interest. The admissions director was impressed by the extent to which the service men have been influenced in planning their engineering-education careers by the type of work they have been doing in the Army and in the Navy. He interpreted the choice in electrical engineering over the other branches of engineering to the fact that the men tend to choose that vocation which seems to them of most immediate practical significance.

Education for "GI's" in Europe. More than 1,000,000 men stationed in Europe have responded to the program of the War Department for an educational plan that will be broad and of practical value when the men return to civilian life. Schools have been organized so that soldiers of varying levels of education can continue their schooling in both academic and in technical subjects. The latter will utilize Army equipment and offer advanced training in such fields as radio, photography, and various types of engines. American colleges and universities have co-operated and business corporations have furnished instructors and materials. The majority of the teachers, however, will be recruited from officers and men now in the Army but a number of leading educators from the United States have agreed to help get the program under way.

Training in Aeronautical Developments. The aeronautical and marine technical school, of the General Electric Company, Schenectady, N. Y., designed to train both civilian and military personnel in installation, maintenance and repair of new fighting equipment, has graduated a total of 559 since inception of the school in 1942. Of the total, 220 have been United States Army and Navy instructors and supervisors, 239 have been engineers of the company and 100 have been representatives of manufacturers. Now in its fourth year, the school has evolved mainly to keep the military abreast of and trained in the use of new aeronautical developments, and to provide scientists of the company and other civilian scientists with a wider and more practical scope of the field and its problems.

Aeronautics Program at Princeton. The School of Engineering, Princeton University, Princeton, N. J., will initiate its first formal graduate-teaching program of its department of aeronautical engineering in November 1945. Emphasis will be placed on those phases of aeronautical science which have been advanced during the war period. Fundamentals will include study of aerodynamic theory, vibrations, and elasticity, and special consideration will be given to such topics as the aeronautical applications of jet propulsion and gas turbines, and modern techniques of flight testing and structural research.

Navy *V*-12 to Continue at Hoboken. The Navy *V*-12 training unit at Stevens Institute of Technology, Hoboken, N. J., will be continued with a quota of 377 men after November 1, 1945. Stevens was designated for the training of engineers at its own request under the Navy College Training Program on July 1, 1943. More than 900 men have received training at the unit, and 292 men have been graduated under the *V*-12 program since its beginning at the institute. Upon completion of the course, and after postgraduate studies at midshipmen training centers, the *V*-12 students are given commissions in the United States Naval Reserve. Although the general policy of the Navy had been to consolidate the program at the end of the summer term of 1945, certain units having Naval Reserve officers-training-corps components, marine detachments, and substantial numbers of upper-level engineers are being continued.

Education Via University Radio. A university radio council to co-ordinate radio activities at Columbia University, New York, N. Y., and to "put education on the air" through its own radio station is a plan of the university announced recently. The university's application for a frequency-modulation radio station has been filed with the Federal Communication Commission, Washington, D. C. The council will be composed of representatives of various schools and divisions of the university, and will be responsible for the control and administration of radio activities. Doctor Russell Potter, chairman of the university's radio committee, declared that through radio Columbia University anticipates bringing to a much larger audience the intellectual, cultural, and scientific resources of the university. It is proposed to broadcast a minimum of six hours daily afternoon and evening throughout the academic year. The station will be on the campus with its transmitter in Alpine, N. J.

RESEARCH • • • • •

Science Offers Choice—Sarnoff

Life or death is the choice facing mankind today as a result of scientific research developed over the past several years and exemplified in today's fateful weapons for war or peace. This is the belief of David Sarnoff (M '23) president, Radio Corporation of America, New York, N. Y., and brigadier general, United States Army, whose article "Science for Life or Death" appeared in the August 10, 1945, *New York Times* with the approval of the War Department.

General Sarnoff urges constant vigilance on the part of the Government of the United States to marshal science and industry to defend itself against aggression. This means not only military preparedness but also scientific preparedness. He urges the engaging in research of the scientific talent of the United States not only in wartime but also in peacetime in order to find the solutions to scientific problems from as many angles as possible claiming that there cannot be too many laboratories. Asserting that the vital role science can play in peace or war for the future calls for consideration of its potential influences upon the territorial, economic, social and political problems that nations seek to solve, General Sarnoff concludes that the "voice of science should be heard in the halls where the architects of peace design our future."

Expansion at University of Pennsylvania. The Moore school of electrical engineering, University of Pennsylvania, Philadelphia, will be enlarged at a cost of nearly $125,000 as a step in the development of its long-established program of engineering research to aid industry, public health agencies, and the United States Army and Navy, according to Harold Pender (F '14) dean of the school. The additional laboratory area will be adapted for research in various phases of electronics, such as television and industrial control, and will be used also for the investigation of problems related to electric machinery. He said that before the war the Moore school laboratories were equipped for both educational and research work in all branches of electrical engineering, and as student enrollment decreased during the war much of this equipment was used for research projects assigned to the school by the United States Government. Many of these projects are being continued while the school is experiencing a steady increase in student enrollment in electrical engineering. Hence the need for additional laboratory space.

New Rubber Silicones. "Silastic" is the latest group of high polymeric organo-silicon oxide polymers to develop from laboratory research into commercial production by Dow Corning Corporation, Midland, Mich. This new silicone rubber now provides a group of engineering materials which remain elastic and compressible at temperatures of 150 degrees centigrade for long periods and can be used at temperatures up to 250 degrees for certain applications. The temperature limitations of natural rubber long have been realized and many attempts have been made to impart to the new organic synthetic rubbers the qualities of increased thermal resistance. In many instances these efforts have been successful in raising the safe operating limits of rubber or synthetic-rubber insulations.

Centers for Oil Research. Plans for construction of two petroleum research centers, one in Linden, N. J., and the other at Baton Rouge, La., were announced recently by Eugene Holman, president of the Standard Oil Company of New Jersey. He said that the program would provide scientists of the Standard Oil Development Company, the central technical organization of Standard Oil Company of New Jersey, with modern and extensive research facilities in the oil business. R. P. Russell, president of the Standard Oil Development Company, said the new laboratories would be used not only for developing improved products from oil and processes for producing them, but also for much work in extending sources of supply of oil products, including gasification of coal, oil from coal, and production of oil from other carbonaceous products.

Research on Steel Planned. A $5,000,000 postwar research and production expansion program has been approved by the board of directors of the Allegheny Ludlum Steel Corporation, Pittsburgh, Pa. A modern research laboratory and related experimental and pilot-plant equipment will be built at Brackenridge, Pa., to intensify studies of the structure, melting, processing, and further development of high alloy steels. A cold-rolling mill of latest design, for rolling stainless and silicon strip steels will be constructed at West Leechburg, Pa.

Starts Work on Research Center. Construction has been started on the research laboratories of the Navy Bureau of Ordnance, White Oak, Md. When completed this project and the Glenn L. Martin College of Engineering and Aeronautical Sciences of the University of Maryland will form one large center of research in the fields of physics and engineering. Captain W. G. Schindler will be in command and Captain R. D. Bennett (F '35) will direct the research.

INDUSTRY • • • • •

Course in Quality Control Methods At Iowa City

An intensive ten-day course, "Quality Control by Statistical Methods," to be given November 6–16 inclusive, was announced recently by F. M. Dawson, dean of the college of engineering and chairman of the committee on quality control, and by Earl J. McGrath, dean of the college of liberal arts, State University of Iowa, Iowa City. The University of Iowa has co-operated with the War Production Board and the United States Office of Education in giving similar courses in quality control by statistical methods.

A feature of the proposed course is a follow-up program in which two two-day clinics will be held with industrial representatives to discuss common problems and to obtain additional information. The course is designed for executives and persons in an advisory position where the knowledge gained can be applied immediately. Tuition for the course, including books and supplies, is $100. Trainees will be expected to provide for their own living expenses and transportation to and from Iowa City. The number of trainees in the course will be limited.

Bendix to Stimulate Foreign Trade. The formation of a new division, Bendix International, to handle the foreign-trade program of Bendix Aviation Corporation, New York, N. Y., has been announced. It will be under the direction of Charles T. Zaoral, general manager, who joined the corporation in January as co-ordinator of foreign affairs, after many years of experience in the foreign field for General Motors Corporation and Dodge Brothers, Inc. The new division will handle throughout the world, with the exception of the United States and Canada, the products of the 17 divisions of the corporation. It has established headquarters at the corporation's New York office and will maintain engineering, sales and service personnel to develop opportunities for two-way international trade.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Role of AIEE in Professional Relations

To the Editor:

In the June and July issues of *Electrical Engineering* are three thoughtful papers, each concerned with the questions—who or what shall become the voice of the profession. Mr. Fairman, in "Organization of the Engineering Profession" (*EE, June '45, p. 220–3*), forthrightly proposes that each individual member of the Institute join the National Society of Professional Engineers. The subcommittee on civic affairs, in "Civic Responsibilities of Engineers" (*EE, July '45, p. 251–2*), suggests the formation of a local engineering council, or club, or society composed of representatives of the local chapters of the national engineering societies and other local technical organizations. The committee on collective bargaining and related matters in "AIEE Report on Collective Bargaining" (*EE, July '45, p. 239–45*) says that an organization of engineers, an association of engineers and employees in closely related professions, and an organization of all professional employees are suitable forms of labor organizations for engineers.

In each case the suggestion is that somebody other than AIEE represent the electrical engineer.

In each case the argument is presented convincingly. Granted then that the role assigned to AIEE administration—the elected and appointed officers of the electrical engineering democracy—is that of a sort of *pater familias* guiding and advising his progeny in their jousts with the outer world, what kind of an Old Man of the Mountain should we develop? Should he be a long-haired, gray-bearded recluse delivering his oracular pronouncements from the shadows of his cavern or castle after being properly propitiated, or should he be a vital, barrel-chested, whooping head-of-the-family ever ready to enter the field of battle with the required club or shield to be shoved into the hands of his sons or even to be used in their behalf? I prefer the latter.

If the common preference is such then AIEE owes its members positive action. If the Fairman recommendation is good—and I for one support it—then AIEE should act by urging and helping its members to obtain professional licenses; by channeling some of its talent into the administration of the National Society of Professional Engineers so as to revitalize that organization; by establishing cross representation with that society on important committees; and by negotiating some sort of dicker whereby dues in engineering societies are not quite so cumulative. There is always the foolish fear present that AIEE may lose prestige or something equally intangible in supporting another body, but a strong outfit strongly in action never loses.

If the civic affairs subcommittee's suggestion is accepted as sound, then AIEE's immediate requirement is to request its Districts and Sections to undertake the formation of technical councils or local engineering societies in the political subdivisions in their area; to aid in forming a loose federation of such councils, to negotiate with the other founder societies so as to obtain their aid; and to develop a means of administering the nontechnical problems that may thus arrive. Again, this approach is nontraditional; there is the ever-present fear that AIEE may become involved in "politics." It probably will and there will be many mistakes made. But at least they will be sins committed and not virtues omitted.

And finally there is the excellent report on collective bargaining. There can be no doubt that it would be a great mistake for engineers to join a union controlled by nonprofessionals. To take the positive position AIEE ought to choose a proper organization for its members and support it. Against this is the old bogey that AIEE contains employers and employees, management and labor. Every engineer—managing director, consultant, draftsman, or test man—is an employee and equally so a part of management. He and his judgment are hired. And what better repository of his interests can any engineer find than the top people of his own profession? In any event this problem as well as the other problems pertaining to the public recognition of the electrical engineer requires, in my mind, a positive AIEE position.

M. D. HOOVEN (A '24, F '44)

(Electrical engineer, electric engineering department, Public Service Electric and Gas Company, Newark, N. J.)

Value of Patents

To the Editor:

What lessons from the war period will our citizens carry with them into the postwar period? One lesson, undoubtedly, will be the need and the value of preparation. Furthermore, the people will have learned the tremendous amount of effort required to achieve a worth-while goal.

Soldiers and sailors in training sacrificed what little time was available for leisure and pleasure to study for higher ratings. They learned to convert time and effort into those higher ratings, which meant greater responsibility, greater authority and larger pay. War workers learned to convert hours of overtime into savings for the future—War Bonds, and savings accounts. The people have been taught to convert toil and labor into an asset and to convert a present sacrifice into a future benefit. They have also been taug that they can expect to enjoy these benefi when the time comes to enjoy them. S should an inventer, also, have the confidenc that he will be able to reap a reward for h efforts, when his invention is adopted b the public. When an inventer sacrific years of time and labor, as well as mone in an effort to develop a new or better de vice, he hopes to be able to convert tha sacrifice and effort into a valuable paten However, there has been a tendency sinc about 1930 to make it more and more diffi cult for an inventer to enforce his paten This has been a result of various court de cisions, and attitudes of officials of certai Government departments.

DECLINE IN PATENTS

When inventers observe the trend t ward depriving them of their reward, the very properly, stop inventing. Inventin fell off considerably during the ten-yea period before the entry of the United Stat into the war. There was a decline of 41[1], per cent in patents issued during the ten-yea period from 1933 to 1943. Since there

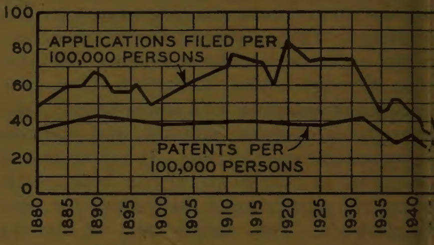


Figure 1

often a time lag of about three years betwee filing an application and receiving a paten there was a close parallel between the declin in issued patents and the corresponding de cline of 41 per cent in patent application filed during the period between 1930 an 1940. The decline during this ten-yea period occurred before there could be any e fects from our entry into the war. Betwee 1930 and 1943, the decline in patent ap plications filed in the United States Pater Office was 54 per cent.

One reason for the patentee's difficulti which discouraged him from inventing du ing this period was the uncertainty whethe a contribution to the art, an advancemen which was considered an invention whe made, would be considered an inventio when the patent came up for consideratio before the courts. Previously, courts ha held that inventions should be judged o jectively by the character of the contributio itself, and tested by the standard of lon standing want and need; by the length time the public had to wait since the previo unsatisfactory device had been propose by the number of prior efforts and failur in the solution of the problem; by t novelty of mode of operation of the inventio and by the copying of the invention by t infringers and an entire industry. Late however, some courts began to adopt t subjective standard of invention; they judg inventions, not by the character of t contribution to the art, or the extent of t advance, but rather by the manner in whic the invention was made, by whom, and und what circumstances.

One of the recommendations of the National Patent Planning Commission appointed by the late President Roosevelt was the enactment by Congress of a rule requiring use of the objective standard of invention. Such a rule would go far toward restoring the value of patents, and should be enacted.

FREDERIC B. SCHRAMM (M '34)

(Patent lawyer, Cleveland, Ohio)

Applications of Thevenin's Theorem

To the Editor:

Walther Richter points out (*EE, March 1945, p. 103–05*) that this valuable theorem has found only limited application in power work because many electrical engineers are not well acquainted with it.

There is another much more recent network theorem, of particular value in communications problems, that deserves the consideration of power engineers. This is the theorem stated by Jacob Millman in his paper, "A Useful Network Theorem" (*Proceedings* of the Institute of Radio Engineers, September 1940, pages 413–17). The author discusses previous application of special cases to unbalanced polyphase networks, and shows that in general the solution of such systems can be quite easily obtained by use of a rather simple network relation.

ROBERT P. OWEN (A '44)

(Electronic engineer, Allen B. DuMont Laboratories, Inc., Passaic, N. J.)

Electrical Essays for Recreation

To the Editor:

Permit me to voice my satisfaction and enthusiasm about something new in *Electrical Engineering*, found on page 294 of the August issue, and entitled "Electrical Essays for Recreation." Material of this sort stimulates discussion and thinking about the fundamental principles of electrical engineering, and should, therefore, be highly welcome. One of the trade magazines, dealing with mechanical subjects, makes it a point to publish a puzzle of this sort every month, inviting discussions from its readers and publishing the solution in the following month's issue. I would like to see *Electrical Engineering* try a similar scheme. By offering a small prize for contributions you might entice your readers to jot down their pet puzzle (and who has not run across some baffling ones?) and to send them in to you. In a similar way, the readers might be invited to send in their solution. The best presented and clearest solution then could be published, or the reader could be awarded a prize.

As to the three puzzles presented by Harry Sohon, the first one reminds me of an incident which occurred some 25 years ago when I was working on the test floor of a large electrical firm in Europe. A young engineer finally had solved the problem of the century; a commutatorless d-c machine. The principle of that revolutionary idea is exceedingly simple. In an a-c generator, a voltage with a given polarity is induced when a north pole of the rotor passes one side of the coil while the south pole passes the other coil side. One-half cycle later, a voltage of the opposite polarity is induced because the poles passing the coil sides are now of opposite polarity. All he had to do was to see to it that only north poles would be passing one coil side and only south poles the other, which obviously was easy to accomplish by exciting the rotor with alternating current of the proper frequency. He had the idea sold to the director of the test floor and carried out the experiment by using a slip-ring induction motor, supplying 60-cycle excitation to the slip rings and driving the machine synchronously. Well, it did not work. No student would have any difficulty in recognizing what is wrong if our schools would cease to explain the law of electromagnetic induction by having a conductor "cut" magnetic lines, but would adhere strictly to the fundamental concept that a voltage is induced when the flux associated with a loop is changing. When adhering to this concept, the student would not overlook the voltage of transformation which is overlooked conveniently in both cases.

Referring to the second puzzle, the two-to-one voltage-ratio transformer, neither my associates nor myself can see any reason why the voltage linking with twice the flux will not be twice as high as the primary voltage. We agree that it might be quite difficult to build a core which will not have a terrific amount of leakage, but with leakage neglected, as postulated by the problem, there does not seem to be any reason why there should not be a voltage step-up.

Referring to the third problem, the power-factor paradox, the "nigger in the wood pile" is, of course, the statement that when the negative half wave of a ten-ampere sinusoidally varying current is suppressed, the effective value will drop to five amperes. It is true, of course, that the wattage will drop to half if current is flowing only during one-half of the time, but as the wattage is proportional to the square of the effective value of the current, the indication of an rms-type meter originally showing ten amperes will drop only to 7.07 amperes when one-half wave is going to be suppressed by the action of the rectifier.

WALTHER RICHTER (M' 37, F '42)

(Electrical engineer, engineering development department, Allis-Chalmers Manufacturing Company, West Allis, Wis.)

To the Editor:

After reading Harry Sohon's essays in the August 1945 issue of *Electrical Engineering* our readers may have many other puzzlers which they will want to submit.

I should like to offer one which has perturbed me and for which I have not yet obtained a suitable explanation.

Assume two electrons traveling adjacent to each other at high speed in a straight line. (This is the case of two electrons in the beam of a cathode-ray tube.) These electrons are moving charges and therefore constitute currents. Hence, there should be an attractive force between them since they are adjacent currents having the same direction. (This is in addition to the normal electrostatic repulsion between like charges.) However, if the observer should travel along at the same speed as the electrons, they will appear to be at rest and he will conclude that for these stationary charges there is no attractive force. Obviously, whether or not this force exists must be entirely independent of what the observer does, so that some fallacy must exist in the above reasoning.

B. LITMAN (A '42)

(Generator engineering, Westinghouse Electric Corporation, East Pittsburgh, Pa.)

To the Editor:

Harry Sohon's "Electrical Essays for Recreation" present three good examples of the result of acceptance of formulas without consideration of the underlying physics. In the first example of "D-C Generator Without Sliding Contacts" the statement appears, "Now the formula for the voltage induced in a wire cutting a magnetic field is $e=bvh$ (equation 3)." This formula applies properly to cases where the flux density is constant, but in this example where the flux density is varied, an additional voltage is induced $e=N\frac{d\phi}{dt}$. It readily can be shown that the additional voltage resulting from transformer action would make equation 4, revised,

$$\begin{aligned} e &= BVh(\sin^2 \omega t-\cos^2 \omega t-\cos \omega t) \\ &= BVh(\cos 2\, \omega t-\cos \omega t) \end{aligned}$$

eliminating the constant term and the direct current.

In the second example, there is no error in the reasoning, and "A Two-to-One Voltage-Ratio Transformer With One-to-One Turn Ratio" is described. The transformer has two turns of the core through one of the coils, which doubles the flux linkages for that coil. The conventional transformer-turns-ratio formula ignores this unusual type of transformer, where the volts per turn are different for the two windings.

In the third example, the incorrect statement is, "The effective current is now five amperes," based on an implied formula that half-wave rectification halves the current. The effective current for the half-wave case is, of course, 7.07 amperes, making the power-factor unity.

ALFRED P. STEENSEN (A '34, M '45)

(Engineer, The Foxboro Company, Foxboro, Mass.)

Name Suggested for Insulated Conductor

To the Editor:

The wire and cable nomenclature lacks a concise term for an "insulated conductor." I suggest "icon" to fill the requirement.

The British use the word "core" for an insulated conductor. "Core" has the merit of conciseness but it is a common word of the English language, meaning the heart or center of anything, and is so used in the United States and in Canada in the wire and cable industry. That is, the core is the inner structure of a cable, about which something is added, as for example, "over the core is applied a sheath or a jacket."

The use of the term "icon" meaning an insulated conductor avoids a common ambiguity, when, for brevity, the word is used in the sense of an insulated conductor. One can use the term "icon" meaning an insulated conductor with assurance that it generally will be understood by one not already familiar with it, as the context and its evident derivation reveal its meaning.

TRACY D. WARING (A '06, M '13)

(Standard Underground Cable of Canada, Ltd., Toronto, Ontario)

Organization of the Engineering Profession

To the Editor:

I read with a great deal of interest an article by James F. Fairman of the Consolidated Edison Company (*EE, June 1945, p. 220–3*). It seems to me he has made suggestions in this article which should receive the support of many engineers, the more so if they are anxious to bring about the unification of the profession. I think you deserve a great deal of credit for publishing Mr. Fairman's article in the journal of a Founder Society. As a matter of fact, membership in the National Society of Professional Engineers should in no way interfere with membership in the Founder Societies. I trust Mr. Fairman's article will receive the general publicity which it deserves.

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NEW BOOKS • • •

The following new books are among those recently received from the publishers. Books designated ESL are available at the Engineering Societies Library; these and thousands of other technical books may be borrowed from the library by mail by AIEE members. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books. All inquiries relating to the purchase of any book reviewed in these columns should be addressed to the publisher of the book in question.

Warships of the World. Edited by R. Kafka and R. L. Pepperburg, with illustrations by D. R. Merrill. Cornell Maritime Press, New York, N. Y., 1944. 1,038 pages, illustrated, 10 by 7 inches, cloth, $15. (ESL.)

This compendium of information on the navies of the world will be useful to laymen and experts alike. So far as is possible, it lists every naval vessel, with facts as to its name, size, horsepower, machinery, armament, builder, and so forth. Each class and type are pictured in photographs and line drawings. Brief accounts of the careers of many fighting ships are given. More than 7,000 ships are included in the book.

Waves and Wave Action. A bibliography of books, periodicals, and society publications appearing from 1687 through December 1943. Compiled by C. C. Lee, 1315 First North Street, Vicksburg, Miss.; revised February, 1944. 91 pages, also pages I–XVIII chronological lists, and A–L subject index; manifold copy, $10^{1}/_{2}$ by 8 inches, paper, $5. (ESL.)

This is a second revision of this list which appeared originally in 1942. Nearly 800 references are listed, the majority with annotations. The arrangement is by authors, with a subject index, and a chronological one.

Aircraft Yearbook for 1944. 26th annual edition. Edited by H. Mingos. Lanciar Publishers, New York, N. Y., 1944. 727 pages, illustrated, 9 by $5^{1}/_{4}$ inches, cloth, $6. (ESL.)

The new edition of this annual publication of the Aeronautical Chamber of Commerce of America reviews the events of the year, both in military and civil aviation, and the work of American manufacturers. Associations, government bureaus, and other organizations interested in aviation are listed with their officers. Statistics and records are tabulated.

Aeronautical Dictionary. By T. A. Dickinson. Thomas Y. Crowell Company, New York, N. Y., 1945. 484 pages, illustrated, $8^{1}/_{4}$ by $5^{1}/_{4}$ inches, cloth, $3.50. (ESL.)

This comprehensive work gives definitions of over 6,000 terms in aerodynamics, meteorology, navigation, piloting, engineering, metallurgy, design, lofting, aircraft construction, and other phases of aeronautics. More than 300 illustrations are used to clarify or amplify certain definitions. An appendix contains many tables of technical data, lists of aeronautical abbreviations, useful books and American periodicals, and other information of value.

Television Programming and Production. By Richard Hubbell. Murray Hill Books, New York 16, N. Y., 1945. 207 pages, illustrated, $3.

Provides a foundation for the techniques of television program production as an aid to broadcasters, advertising men, writers, directors, actors, designers, students, technicians, and theatrical, radio, and motion-picture people in building their television programs and projects more ably and more rapidly. Suggests practical ways in which these techniques may be improved. As an introduction to the art of television this book discusses the nature of television; the camera; video technique and theory. The last part of the book is devoted to a retrospect of television programming in England and the pioneering efforts of the British Broadcasting Corporation.

Gas Turbines and Jet Propulsion for Aircraft. By G. G. Smith. *Aerosphere*, Inc. 370 Lexington Avenue, New York, N. Y., 1944. 123 pages, illustrated, $8^{3}/_{4}$ by $5^{1}/_{2}$ inches, cloth, $3. (ESL.)

The history of the development of gas-turbine prime movers employing jet propulsion is presented concisely with considerable technical detail. Examples of gas-turbine units driving orthodox airscrews are included, and steam turbines are briefly reviewed. The work has been revised generally, and three new chapters have been added on turbine-compressor units, jet versus airscrew, and boundary layer control. An interesting feature is the discussion of the future possibilities of the gas-turbine power unit in the flying-wing type of aircraft.

Mechanical and Electrical Equipment for Buildings. By C. M. Gay and C. De van Fawcett. Second edition. John Wiley and Sons, Inc., New York, N. Y.; Chapman and Hall, London, England, 1945. 453 pages, illustrated, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, cloth, $5 (ESL.)

The coverage of this manual is indicated by the headings of the five sections: water supply, plumbing and drainage, heating and air conditioning, electric equipment, and acoustics. The purpose of the book is to acquaint architects, students, and building managers with the basic theories and applications concerned with building equipment, rather than to provide a handbook for complicated design and specifications. This edition has been rewritten considerably to conform with modern practice and the latest recommendations and provisions of the pertinent codes and standards.

Aerosphere, 1943. Edited by G. D. Angle and others. *Aerosphere*, Inc., 370 Lexington Avenue, New York, N. Y., 1944. Paged in sections, illustrated, 12 by $8^{1}/$ inches, cloth, $15. (ESL.)

Aerosphere provides brief descriptions of the aircraft and aircraft engines currently being built throughout the world, together with statistical information on these industries and a buyer's guide. The arrangement is by countries, then by manufacturers. The specifications, construction, equipment, instruments, performance, and engine for each model are stated, usually with a photograph of the plane or drawing of the engine.

Electrical Essentials in Marine Service, Volume 1. By J. M. Dodds. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1945. 419 pages, illustrated, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, cloth, $3.

This first of three volumes gives a thorough reference-handbook treatment of all phases of marine electrical work except radio for use by marine and shipyard electricians engaged in installation, testing, repairing, and maintenance work. This volume—easy to read, easy to understand—explains the essential principles of electricity and magnetism and the characteristics of electric circuits. Alternating and direct currents are discussed together and their various uses described and compared.

PAMPHLETS • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

"Full Employment" and the "National Budget." (A Discussion of the Murray Full Employment Bill.) Citizens National Committee, Inc., Washington 9, D. C., 24 pages.

Modern Governors (For Large Hydroelectric Units Provide Centralized Control). Allis-Chalmers Manufacturing Company, Milwaukee, Wis., 24 pages.

The Use of Public Works to Sustain Construction Activity. Chamber of Commerce of the United States, Washington, D. C., 12 pages.